AMERICAN GEOLOGY,

CONTAINING A

Statement of the Principles of the Science,

WITH FULL ILLUSTRATIONS OF

THE CHARACTERISTIC AMERICAN FOSSILS.

ALSO

AN ATLAS AND A GEOLOGICAL MAP OF THE UNITED STATES.

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PART II.

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AMERICAN GEOLOGY.

PART II.

THE TACONIC SYSTEM.

PRELIMINARY OBSERVATIONS.

§ 1. We are now prepared to engage in that part of American Geology which treats of the sediments. It comprehends the third division in the proposed classification, the *hydroplastic rocks,* or those which have been laid down in and moulded by water. They usually contain in themselves the evidence of their origin. Their component particles have been rounded by attrition. There are exceptions, however, to the rule, but even in those masses which are exceptions, they are so connected with those that are made up of sediments that we need not be led into error in their determination. The attestation of their origin by pebbles is usually confirmed by the presence of fossils. Fossils may be contained in the pyroplastic rocks in consequence of their having overflowed those places where they were collected upon the surface; but such instances are comparatively rare, and speak for themselves. Neither fossils nor pebbles are ever found in either division of the pyroplastic rocks.

The deposition of sediments has been in progress without interruption since water began to accumulate in seas and oceans. This accumulation has not progressed at a uniform rate, neither have the same areas been under the dominion of water during this entire period. Oscillations of land have often occurred, so that in fact the oceans may be said to have traveled sometimes to the east and sometimes to the west, but moving in obedience to those subterranean forces of which I have already spoken.

These movements are indicative of stages in geologic time. They seem to have often been paroxysmal, and to have been followed by periods of repose, during which sediments accumulated quietly upon the ocean's bottom.

The sequence in which the sediments have followed each other, has been an important geological problem. The best evidence of sequence or the order in time in which rocks have been deposited, is superposition, or the association of the fragments of the older with the newer rocks. Succession is often indicated when the overlying mass contains the materials of the older or inferior rock. Sedimentary rocks are the only ones which are stratified, stratification implying a succession or accumulation of materials under water, which are spread out in thin strata over the ocean bottom by the same agent. Different strata are indicated by the different materials received from the land. Sediments require to be studied with reference to their kinds, their source, their texture, the rapidity of their accumulation, and the time they were forming, and their order of succession.

The first two will give us information as to the direction in which the land lay which furnished the sediments; the third the probable distance they were transported; the fourth, with information respecting the force and rapidity of the transporting streams and currents, and the probable existence of floods alternating with drouths. Sediments are measuring lines, all things being equal; they reach into past time directly according to their thickness. The table of arrangment of rocks shows that the older sediments are thicker in their periods and stages than the new. Comparing the Palæozoic with the Kainozoic sediments, the disparity is immense. The divisional lines of the great triads of past time, as measused by the sediments, show a rapidly diminishing rate from the bottom to the top. The base is immensely spread out in the Taconic system, but the systems converge rapidly from the carboniferous, as if in the long preparatory stages for man's entrance upon the scene of earth's conflicts, nature had become impatient, hastened the later periods to their ends by crowding the greatest events into smaller spaces.

§ 2. But it is not with sediments only, that the geologist has now to deal. In the sediments are the vestiges of life. Since the sediments began to collect, we know that this new element was introduced upon the globe. But life does not seem to have begun with the sediments, for they appear to have been accumulating for immense periods before we find even traces of it in their beds. The precise time is not yet determined, but it appears now that it was clothed in a humble dress, that it began in the lowest rank both in vegetables and animals, and that they began simultaneously and as occupants only of the seas.

Sediments, are distinctly separated from the massive and laminated igneous rocks, and the line of demarkation is well defined. We have therefore a distinct sedimentary base.

§ 3. Life, beginning in the sediments, has also a base which is termed the *palæozoic base.* The use of this term seems to imply that there is also another base, but it means simply, the period when life first appeared upon the earth. Virtually, however, we may work instructively from a mesozoic or a kainozoic base; for in either case, it is possible to make comparisons of the organisms in their aggregate belonging to either of those divisions. It is well established by observation that the organisms preserved in each of these grand divisions differ on a whole from each other.

Sediments, taken in conjunction with life, are the elements of our knowledge of geologic time, or the events which occurred long prior to the historic era. Since the historic era, events strictly geological have been recorded with the passing events of the day. But the events prior to history are recorded only in the physical phenomena in the earth's crust. Their interpretation is the highest duty of the geologist. As an illustration of interpretation of phenomena we may cite the occurrence of volcanic dust as interpolated in beds among the sediments; or, the flexures and wrinkling of strata, the first showing the activity of volcanic forces in past time similar to that of our own, the latter also of earthquake movements, differing in no respect in kind from those of the present. The course of nature therefore, in the long run, has been uniform. It has been governed by the same laws in the remote, as in recent times. Life, it is well known, does not admit of wide deviations from certain normal conditions of the earth's atmosphere or its waters. The limits within which the integrity of vital forces can be maintained, are within narrow bounds. Hence, its frequent interruption. The types of animal and vegetable life are few, and however protracted time has been in the past, they have never been increased since the middle of the Silurian system was laid down.

Perturbations of the earth's crust are cotemporaneous with the changes in the organic world; they seem to mark the outgoing and incoming of the geologic periods. The systems are particularly indicated by physical changes. Hence the outgoing of organic forms are connected together as cause and effect with the perturbations of the earth's crust. We are not, however, to carry this doctrine too far; facts seem to show that many species survive a perturbation, and in historic times species have become extinct from causes which can not be traced to perturbations of the earth's crust.

The sediments with their organisms is a richer field for thought than the pyrocrystalline masses. The former, it has been aptly said, contain the medals of creation.

OF THE OLDEST SEDIMENTS. COLLECTIVELY THEY FORM THE TACONIC SYSTEM. ITS BASE, AND THE ORDER OF INVESTIGATION, ETC.

§ 4. My first business is to sketch a picture of the oldest of the sediments, as they are exhibited in a series which collectively constitute the Taconic system, and as it is developed in the Taconic ranges of Berkshire and the adjacent country immediately north and south. It is of the first importance to state the constitution of the masses, and to connect therewith a statement of their relations, as they appear, in the order of their sequence, taking occasion also to make such comparisons with other systems, as the nature of the facts and phenomena require.

The natural order, and the one which should be followed, is to begin at the base. We then follow up the series in the order of events. It is impossible to work down to a base; certainly such a course deprives us of a continuous narrative; it would be like reading American history backwards—beginning with Franklin Pierce and going back step by step, to George Washington and the events of the Revolution.

The Taconic system has a clear and well defined base, which is rarely obscured by passages into the primary schists, the pyroplastic rocks, sienites or granites. We have no intermediates, and no masses which may not be distinguished, either by their composition, or their relations to conglomerates and pebbly beds, the invariable characteristics of sediments. It appears therefore, that we are justified in the conclusion, that when the base of this system was laid down, water had become an established element upon the face of the globe, not subject to dissipation in vapors by excessive heat of its crust, for the pebbles in the rocks exhibit an attrition similar to what takes place upon our shores at this day. If my views are correct, and I have endeavored to sift them of error, we can go back no farther; we have no older sediments. When, in 1836, I determined that in New York, the Potsdam sandstone was the base of the Silurian system, it seemed that we had at that time, the base of the sediments; but, when, two years subsequently, I had observed the same base resting on sediments still older, as those along the eastern side of Champlain and elsewhere, it became evident that there was still a series older than the Silurian. The proof of this has been accumulating ever since; and the Taconic system is found to rest upon primary rocks without an exception; and it has now been observed through the whole length of the states, from N. E to S. W. It is worthy of note, that through this whole extent, the base is continuous. The most northeasterly point at which I have observed this system, is at the Fox Islands, off the coast of Maine; but I have good reason to suspect its existence in Newfoundland. If so, it ranks among the most persistent geological formations of this country.

§ 6. The evidence of the existence of a system of rocks, beneath and older than the Silurian system in this country, rests on many well determined facts. These facts are not all of equal importance; but those which are not direct. serve to corroborate and sustain those which are. The facts which bear directly upon the evidence alluded to are superposition, succession, unconformability and the presence of fossils distinct from those of the Silurian system. Those which corroborate and sustain the independent existence of the system are, a thickness greatly superior to the Silurian system, an arrangement of its masses quite different from the latter, and the absence of fossils where they should exist, provided there is a correlation of the two series. The foregoing views will appear more conclusive when we take into account the fact that the lower Silurian rocks of this country, consist of well determined members through their whole extent; they are arranged in a determinate order, and hence are more easily recognized by their fossils, and also by their lithological characters. The lower limestones, it is true, are not eminently rich in fossils at every location, but they may be discovered by careful search, and moreover the true calciferous area, if wanting in fossils at any given place, is readily known by its relations. The present advanced state of the science requires of the geologist no better evidence of age, or a better foundation for establishing the age and infra position of the Taconic system, than the determination of the foregoing facts. This is especially true, when we have sifted our observations of certain errors which might occur in regard to superposition of an older rock upon a newer by excessive derangements. Fortunately, the most important points where superposition and succession occur, are those of only moderate derangements; indeed, the phenomena neither indicate excessive upheavals, nor downthrows, the sliding of the inferior mass upon an older, the passage of an anticlinal axis into a fault, nor the deceptive plications of contiguous strata; nor lastly, the folding beneath of a superior mass, or what we may possibly deem the mistaking of cleavage planes for those of deposition. When our observations are free from the possibility of error of the foregoing kinds, we are forced to maintain that superposition is due alone to succession; or we are forced to concede one of two things, either that there is a system of rocks older than the Silurian, or else that it is possible that to the Potsdam sandstone there succeeds conformable slates, limestones, conglomerates and sandstones whose joint thickness is between 25,000 and 30,000 feet, forming a prodigious appendage to a system whose base, all admit, is the Potsdam sandstone.

Lithological characters should not be neglected, though it is true, that in cabinet specimens no reliance can be placed upon these characters; yet in the field and when investigated in mass, they really become important aids in clearing up the difficulties which lie in our path.

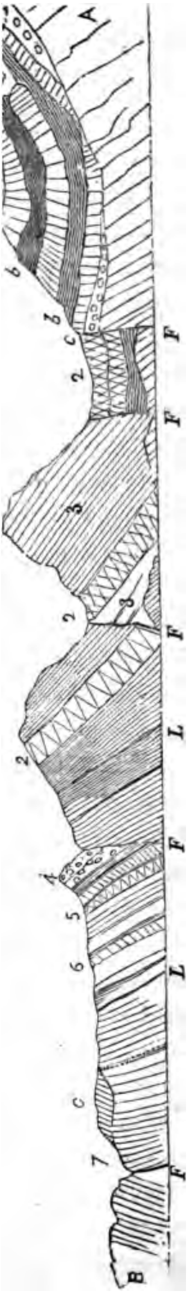
§ 7. If it was my only aim and object to place the evidence I have of an independent system of rocks beneath and older than the Silurian, I should proceed to point out at once, that there is a slate beneath and older than the Potsdam sandstone, or in its absence, the Calciferous sandstone, and that a succession of rocks of great thickness lie in conformity to this underlying slate; and farther, that the members constituting this system, are never incorporated into the Silurian, or lie in conformity therewith; or stand in the relation of sequents to any of its members. This slate I should select because its position would enable me to exhibit its relations to the lower Silurian rocks, and this would be the more satisfactory and conclusive, inasmuch as it is maintained that the Taconic system is only the lower Silurian, embracing those members which lie between the top of the Hudson river group and the Potsdam sandstone. I shall not however pursue this plan, as I wish first to exhibit the sequence and relations of the members composing the Taconic system. In this country, seeing that the lower Silurian system is remarkably well developed and defined, it has appeared to me that American geologists should avail themselves of this fact and employ it as one of the instruments or means for the determination of the true palæozoic and sedimentary bases. It certainly gives us important advantages over European geologists. The bases of both systems are remarkably well defined, and the arrangements of the lower masses in both are so uniform that a comparison in detail is by no means difficult. This is true even in the disturbed districts. We may admit the existence of folded axes, or, that in the eastern district the masses are metamorphic, still the comparison of one with the other need not involve us in error.

ROCKS WHICH GENERALLY COMPOSE THE TACONIC SYSTEM.

§ 8. The sediments of all systems must necessarily consist of the same materials. Sandstones or the debris of the silicious rocks, limestones and slates with various intermixtures must make up, lithologically, the matter which compose them. Conglomerates and breccias are also constituents in a less amount and degree, yet not less important geologically, as they serve to mark more distinctly the physical changes which have taken place in the course of time, and during which the depositions have been going on.

The important point to be observed is the arrangement of the materials, although in the same system at different places there may not be a parallelism of deposits, yet there is a great similarity in districts which are widely separated. The Silurian system in this country is quite uniform as to the arrangements of its subordinate members — the northern limits of the system in New York is almost identical with the same part of it in Virginia and Tennessee; this is especially the case in the lower Silurian. The Potsdam sandstone, the calciferous, birdseye, Chazy, Trenton, and the upper slaty and shaly masses, can not be distinguished from each other at these wide distances. I am not called upon to account for this remarkable fact. I have only to state it in this place. This constancy of mineral character becomes an available fact, where it is necessary to compare the corresponding parts of two adjacent systems. For example, a comparison of the lower members of the Taconic system with those of the Silurian in this country shows a decided difference in the mineral constitution. The first partakes of the primary character of the talcose and mica slates of the pyrocrystalline rocks; indeed, it is often difficult to distinguish the lower slates of the Taconic system from the schists which are intimately connected with the gneiss and hornblende. So close indeed is their resemblance that they were regarded by the old Wernerian geologists as primary rocks of the same age as hornblende and gneiss; and the same is true of the quartz rock occupying the same geological position. When, however, we examine the lower Silurian masses their origin is not doubtful; they all bear the impress of a sedimentary origin. This difference has usually been explained by metamorphism. This explanation, however, is not satisfactory, inasmuch as the base of the Silurian system in northern New York reposes on the pyrocrystalline rocks, and so far as we at this day are able to judge of cause and effect were as likely to have become metamorphic in this region as the lower Taconic rocks. It has appeared to me, therefore, that the difference in physical condition is due mainly to composition. The lower Taconic rocks are derived directly from the pyrocrystalline rocks, granite, gneiss, mica and talcose slates; and the latter being very uniform in composition through the whole length and breadth of the Appallachian system of mountains, the source from whence their materials were derived, they have of necessity a constancy of mineral constitution. So also the same accounts for the constancy of the mineral constitution of the lower Silurian, whose materials have been derived from the Taconic system in a parallel belt and of an equal extent; and this view is by no means theoretical. Years ago, I had obtained masses of a gray sedimentary limestone from the lowest part of the Silurian system at Chazy, which resembles most perfectly the limestone of the Taconic system in the neighborhood. The carboniferous system of Rhode Island is in part composed of talcose slates which contain the stems of lepidodendra; so in the masses of conglomerates of the same system at Wrentham, Mass., masses of talcose slates are by no means uncommon. All these variations of mineral constitution have been attributed, as I have already said, to metamorphic action. I can not but regard it, however, as erroneous in all the cases I have cited. While I recognize metamorphic action as important, I can regard it only as a local result, and limited in its effects. At most, such seems to be the ground upon which it is to be placed in this country; and hence, in comparing the lithological characters of the systems, it is more important to notice the mineral constitution of their masses. This mineral constitution, I maintain, is not a secondary affair. If, for example, we find magnesia as a constituent of the limestones or talcose slates its presence is to be regarded as having coexisted in the sediments, and not as material which has been introduced subsequently through the influence of chemical and physical forces.

§ 9. The rocks which compose the Taconic system are sandstones, often vitrified; slates, both green and black, the former varying somewhat in constitution, in some instances they are talcose or magnesian, in others argillaceous; and others still may more properly be denominated chloritic; and limestones purely



carbonates of lime. containing beds of dolomite, black slates colored with carbon, and decomposed sulphuret of iron, and calcareous sandstones. Subordinate to these rocks, I may also enumerate fine and coarse conglomerates, breccias, limonites, and schists of various colors. The system contains also veins of magnetic and specular iron, auriferous and cupriferous quartz veins, and in the metalliferous districts sienitic and compact trap dykes.

§ 10. The general order in which the rocks are arranged is exhibited in figure 1.

1, conglomerates and breccia at the the base of the system. The iron breccia and limonite veins occupy this position; so also quartz in the condition of an ordinary sandstone or an even bedded flagstone; and I may also add talcose or magnesian slates alternating both with the quartz rock, a, c, d, and the subsequent members; 2, limestones; 3, slate, which in its usual enormous development seems to constitute the principal feature of the system; all the other masses might be regarded as subordinate beds; 5, slates, which I have denominated Taconic slates, and which are usually of a dark color, and contain beds of sandstone, sometimes a purely silicious rock, at other times they are silico calcareous; 6, sparry limestones in the Taconic slates; *L*, limestone; *F*, fractures.

This section exhibits the order of arrangement, or the sequence of the members. In certain geographical districts it is in proximity to the primary schists and granites, as in North Carolina and Maine; in others, to the primary schists and the carboniferous, as in Rhode Island, and New York, Virginia, Pennsylvania and Tennessee, to the Silurian and carboniferous.

THE GENERAL GROUPING OF THE MEMBERS OF THE SYSTEM, OR THE DIVISION WHICH IS PROPOSED FOR THE TACONIC ROCKS.

§ 11. The Taconic system is susceptible of a division into two parts, the lower and upper—the line of demarkation is tolerably well defined. The first or lowest division terminates with the slate overlying the Stockbridge limestone, 2, 2. The entire mass of this division exhibits the primitive schistose aspect of the laminated pyrocrystalline rocks, and were it not for the presence of conglomerates in this formation, it would still be regarded as belonging to a period in the earth's history which preceded the deposition of sediments. As the phenomena exist, however, it must be regarded as the sedimentary base of all of the hydroplastic rocks. It is in the upper part of the second division that we first find fossils, the fucoids and graptolites of the Hoosick roofing slate and the adjacent beds of the same period. This fossiliferous part of the division still retains in part the primary aspect of the lower beds, but the colors of the slates are darker, some are purple and chocolate colored, and the sediment is much finer, and more homogeneous. In this part of the system, therefore, the rocks are coarse in texture at the base, and become finer and homogeneous in the ascending scale. Oak hill itself, with its adjacent mountains of protogine and gneiss are the most interesting localities for an exhibition of the arrangement of the lower Taconic rocks, in this county. It exhibits the junction with the protogine, the order of arrangement of the members nearly to the first limestone. This order is exhibited in figures 1 and 2. But there remain several facts connected with the localities which require a farther statement. In addition to the dip of the several masses exhibited upon the first section, there is a steep southern slope upon which the masses plunge rapidly, and beneath the narrow valley leading from Williamstown to North Adams, the formation exhibited upon the western slope of Oak hill is lost, in part, beneath the soil of the valley. The upper mass of quartz may be seen near the Adams road, not far from the bridge crossing the Hoosick.

The out crop of the quartz occurs again two miles south near a mill at the junction of the Hopper creek and Green river. A small part only of the mass is exposed dipping southeast and towards the high range of mountains known as Saddle mountain and Graylock.

The upper division begins with coarse slates and sandstones, and terminates in a fine black slate. These sandstones and slates are greenish, and rather chloritic than talcose; and the masses, as a whole, often resemble greenstone. This appearance is no doubt due to the presence of chlorite and perhaps the debris of hornblende. In New York these rocks are by no means altered rocks; there are no veins of greenstone or porphyry in connection with them. The upper part is much more protean than the lower. Dark colored slates predominate, but they contain a multitude of subordinate beds, as olive sandstones, intercalated with fine green slates; calcareous sandstones, which weather to a brown or drab, dark green flags with fucoids; sparry limestone; green and black slates; beds of quartz free from calcareous matter; beds of conglomerates and black shaly limestone, which occupy a superior position in the series.

These beds are also interlaminated with a thin bedded sandstone, which we may not be able to identify at distant points, or which may prove to be due to local variations, and not persistent at distant points.

MEMBERS OF THE LOWER TACONIC SYSTEM. THEIR CONSTANCY OF MINERAL COMPOSITION. THEIR THICKNESS. ABSENCE OF ORGANIC BODIES.

§ 12. The principal members of the lower Taconic system are few in number, for though the beds are numerous, it is not deemed necessary to multiply names of rocks where there are no fossils, and when the differences are due to position only. For example, it is difficult to distinguish the beds of slate which lie between the masses of quartz, from those which overlie the limestone. It seems to be one rock prolonged through a long period, the continuity being broken occasionally by a substitution of silicious and calcareous deposits.

As the masses referred to possess characters which are essentially the same from Maine to Georgia, I shall select for description a section which I have worked out in detail, and which is also accessible to those geologists who have sufficient interest in these rocks to examine and test for themselves the truth of my statements. A brief reference will also be made to the same rocks which are situated at distant points.

The second line of section which I shall now describe, extends also through the north part of Berkshire county, Mass., and immediately across Prospect hill, S. E. of Williams college.

§ 13. The western declivity of this mountain furnishes the necessary information relative to succession of the limestones and slates, which are superior to the rocks of Oak hill. This succession has been satisfactorily made out and is exhibited in section 2. It passes directly over the mountains a little to the north of Graylock, so as to cross the valley about two miles south of South Adams. The dip of the limestone, quartz, &c., near the mill referred to, is S. E., the limestone reappearing on the Adams side of the mountain in a reversed dip, forming therefore in the range of mountains through which it passes, a synclinal axis. The rock above the limestone is entirely slate and can scarcely be distinguished from primary talcose slate, and yet it is a sediment. The height of Graylock above the outcropping of the limestone is 2000 feet. The limestone is 500 feet thick, and the mass between the limestone and upper bed of quartz is at least 500 more.

On the east side of the valley, near South Adams, the rail road cutting exhibits a fine section of slate; it dips westward steeply, and behind it towards Hoosick mountain, which is composed of gneiss, the limestone and quartz reappear in their true relations. These rocks therefore do not dip towards the primary range, but westward.

§ 14. To enter now upon an enumeration and description of ıbers of the lower division as they occur in an ascend-er, I proceed to speak of them as developed in Williams-ıd Adams, and to which an allusion has been made.

he lower rock or base of the Taconic system at these is a quartzite. The propriety of the name rests on the fact, that quartz in some form is the predominant element. The inferior mass is sometimes a slate in which talc is abundant, and which generally contains pebbles. Lithologically, it is a silicious talcose slate, closely resembling the talc-schists of the primary rocks of which hornblende is one of the associates. At or near the base we find beds of conglomerates, which are usually made up of rounded quartz pebbles, as well as angular stones imbedded in a talcose paste. Another brecciated conglomerate consists of a paste of limonite in which both rounded and angular masses are enclosed. Proceeding from the base upwards, the masses consist of quartz of various colors and degrees of fineness, alternating with talcose slate. Associated with them in thick beds, is a quartz charged with feldspar, which often looks like a porphyry. The feldspar decomposes and leaves small ragged cavities, when the mass becomes a *burrhstone*, and is often used as a millstone. The quartz rock is granular, often friable, vitreous, and compact; usually brown, but frequently gray or grayish brown, or white; sometimes snow white, and an excellent material for glass. The different varieties appear to occupy a given place in the series, but the vitrified kinds do not lie at the bottom, but frequently occur at the top; and so, of the distinct sandstones or friable ones, the beds are more frequently at the bottom, or near it. The grains have the form of the common sandstone of the Silurian system. Hence the vitrified masses became so by circumstances which attended their deposition, rather than by a subsequent vitrification by heat. So much do the bottom rocks appear like primary rocks, that no one would suspect they were sediments, were it not that they are accompanied by conglomerates. The conglomerates are sometimes obscure, in consequence of a thin investment of talc, which often appears pressed into the pebbles. Among the pebbles, angular masses of quartz and hard green slates are often found so closely resembling the accompanying talc-slate, that it might be inferred, that the slate had been broken up and incorporated with the mass, but it is probable that they belonged really to the primary schists which accompany hornblende and gneiss.

§ 15. That the character of these lowest sediments may be clearly distinguished from the lower Silurian, I propose to speak of them in greater detail: Fig. 1.—1. The lowest mass and which reposes upon protogine about one mile east of the crest of Oak hill, is a porous silicious slate, composed of talc, and some mica, quartz and feldspar. The feldspar and quartz is angular, sometimes the particles are rounded, but in either case the rock has an open structure arising from the decomposition of feldspar, and the small cavities are rough and unequal. The porosity of the mass fits it for a millstone. It is a thin mass at this place. At other places its pebbly character is remarkably well developed. It lies directly upon the granite here and its materials clearly indicate that it was derived from this rock. Its thickness is variable, not exceeding thirty feet at this place.

The mass reposing upon this millstone is, 1, a coarse slate made up of talc and quartz, it is a talcose slate. Its stratification is uneven from the presence of coarse masses of quartz. We meet occasionally with needleform schorl. It is a much more crystalline mass than the slates above it. It is seventy feet thick. 3. The next rock, c, is a sandstone. It is made up of white quartz grains, and forms a flagging stone susceptible of division into very thin layers. It seems to be purely a sandstone unchanged by metamorphic action. It is 100 feet thick. thick. It dips southwestwardly at an angle of 15°.

The fourth rock, b, is talcose slate. It is gray, soft, and even bedded. It is comformable to the masses below it. It is forty feet thick. 5. A mass of quartz, d, succeeds this fine slate. It is brown and rather massive and jointed. It is fine grained, and destitute of pebbles. It is 400 feet thick. It extends nearly to the crest of Oak hill when it slopes to the south, but there still overlies it a bed of quartz and a silicious talcose slate which seems to be the remains of a much thicker mass; the latter is about thirty feet thick, and lies obliquely across the axis of the hill. The strike of the rocks therefore is not coincident with the ridge or crest of this chain of hills, the former bearing a few degrees more to the westward.

The masses which I have described crop out upon the east side of the ridge and dip S. W. at a moderate angle. They reappear on the west side again dipping eastward, forming in consequence of their opposing dips a synclinal axis. Oak hill is 1700 feet above the valley of the Hoosick, which flows at its western base, but the rocks are exposed only at or near its crest on the west side, while on the east side the succession is perfectly clear by an exposure of all the masses from the protogine to the top of the mountain.

§ 16. The sequence being made out in the mode I have stated, it becomes necessary now to ascertain what rocks succeed those which have been described. This determination may be satisfactorily made out by tracing these same masses along the southern slope of Oak hill into the valley already referred to as leading from Williamstown to North Adams. We learn from the direction they take that they plunge beneath Saddle mountain, and by tracing some of the members already spoken of along the western flank of this range, we at length find the quartz outcropping in a small creek which comes down from the hopper of Graylock the summit of Saddle mountain, and the highest point of land in Massachusetts. This point is 3600 feet above tide, and 2800 above the Hoosick. It forms a heavy mountain mass between Williamstown on the west and South Adams on the east. By ascending the western slope of Saddle mountain to Graylock, from the quartz which outcrops at its base, we obtain the succession of the masses which succeed the formation of Oak hill. The rock overlying the quartz is again talcose slate, silicious at its base, but purely a talcose slate as a mass and which requires no farther description. It is between

400 and 500 feet thick and extends up to the limestone, which constitutes the seventh member of the lower Taconic system.

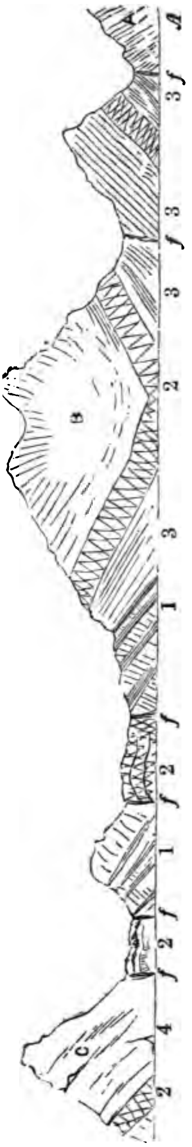
This limestone, in a former treatise upon the Taconic system, I denominated the Stockbridge limestone, as it is extensively known in the commercial world as a marble and a valuable building material. It is however less constant in its composition than we should expect judging from the pieces of marble exhibited in market, or at New Ashford. It is in the first place frequently a dolomite, and in this composition is flexible when first removed from the quarries. Its layers along the plane of bedding are profusely sprinkled with green talc, and though in Berkshire county it seems to be confined to one mass, yet at other places not far distant it is interlaminated with slate.

The colors are white, gray and occasionally very dark. It is reddish at Williamstown and is intimately blended with silex. It is also seamy or sparry, containing calcareous spar, magnesian spar blended with a variable quantity of carbonate of iron.

It crops out on the western slope of Saddle mountain dipping south of east, but on the east side at South Adams it crops out at its eastern base, dipping west. Its limits and position are clearly defined at Williamstown and Adams, and indeed for the whole of western Massachusetts and eastern New York, as it is found in the same relation throughout this entire region. It is 500 feet thick as exposed on the western slope of Saddle mountain.

§ 17. The eighth member of the lower Taconic system which succeeds the limestone already described is a talcose slate. From the termination of the limestone to the top of Graylock, the talcose slate is uninterrupted. The thickness of slate above the limestone is about two thousand feet. These beds of slate are similar and uniform in their composition and structure not only in Berkshire county, but in Virginia, North Carolina and Tennessee; the beds at the south can not be distinguished from those at the north.

By referring now to fig. 2, the reader will see at a glance the relative position of the rocks which I have described.



1, 1, Quartz with its interlaminated slates, at the foot of Saddle mountain; 2, 2, limestone outcropping upon both sides of this mountain; 3, 3, slates beneath and above the limestone. I have also shown in the section the relative position of the mountain ranges which traverse Berkshire county and eastern New York. A, Hoosick mountain composed of gneiss and mica slate, hornblende, etc.; B, Saddle mountain; C, the main belt of the Taconic range along which runs the boundary line between Massachusetts and New York. This range, C, is composed of the same talcose slate as B. It is another uplift of the same rocks. In the valley between, Stone hill forms a prominent point and shows a repetition of the rocks of Oak hill. It is 400 feet high and is bounded on both sides by the limestone No. 2. This limestone is crushed and contorted.

The prominence represented between A and B is a sharp ridge in South Adams, on the west side of which the rail road cutting exposes the slate dipping steeply to the west.

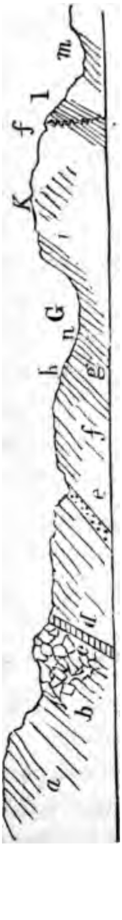
§ 18. *Iron breccia of the Taconic rocks.* This singular mass should not be passed by without a brief notice. It is composed of angular quartz cemented together by limonite, or brown hematite. It does not form as I have ever been able to find a continuous stratum, but it is associated with this part of the series. It occurs in Vermont, Massachusetts, Pennsylvania, Virginia, North Carolina and Tennessee, and always in the same relation. At North Adams it was worked for iron at one time, a thick seam of it being discovered in ce near the junction of the slate and quartz. It is always too cious however to be profitably worked. Its origin is unquesıably igneous, as the phenomena seem to indicate at the lity just referred to, and it also seems highly probable that the immense beds of limonite which extend through the states I have named above have been derived from the originally injected masses of iron breccia. However this may be, the mass is highly interesting. It is easily recognized as it is composed of quartz and iron. The quartz is sometimes in rounded masses as in Hillsborough, N. C, and hence is a conglomerate. Ferruginous quartz also occupies the same geological position and is as widely distributed. It is common in Berkshire, Mass., Buncombe county, N. C., and near Abingdon, Va.

§ 19. The sequence of the lower Taconic rocks which has been stated and illustrated in the foregoing pages is essentially the same from Maine to Georgia. I shall illustrate this position from the careful observations which I have made in this and in former years. The order of arrangement, therefore, which has already been placed before the student, must be regarded in no other light than as confirmatory of the views I have adopted in this and my former treatise upon this system.

§ 20. *Taconic rocks in Maine.* The Taconic system is surrounded by primary schists, granite, &c. I have been unable to discover any masses which could be referred to the Silurian system. The earliest information respecting this system in Maine was communicated by Dr. Jackson. The discovery of fossils, which were regarded as vegetable impressions at the time, were subsequently referred to the class of Nerecites. At this time they may be placed among the foot prints of moluscs. The slates which contain them are at Waterville, on the banks of the Kennebeck. They are soft, green talcose or magnesian slates, placed nearly in a vertical position and whose trend is N. 10° E. They are connected probably with the fine roofing slate of the Piscataqua river. They seem, however, to be isolated and separated from the lowest members of the Taconic system. The slates extend over a width of country, for about 15 miles. It is at Camden, however, that we observe a section of the rocks which coincides with those of Berkshire county. The intervening country is partly covered with drift, over which granite, gneiss and mica slate prevail.

ıe of the most interesting rocks of Camden forms a very nspicuous mass in the neighborhood. It forms an eminence 700 or 800 feet high. It is the Megunticook mountain, d is a mass of conglomerates resting unconformably upon mica ıte. It is isolated, and the members once connected with it ve been swept away by diluvial action. The conglomerates e at least 400 feet thick. A large proportion of the quartz is ll angular. A succession of the lower rocks of the system is :posed on Goose river and harbor in the vicinity.

Figure 3 shows the succession referred to, enumerating them the descending order.



a, wrinkled magnesian slate; *b*, limestone; *c*, trap dyke; *d* and *f*, slate more or less silicious; *e*, granite vein; *h*, hard quartz rock; *i*, slaty and contorted quartz; *l*, slate containing imperfect macles; *n*, second mass of granular quartz; *m*, magnesian slate. At *F* there is probably a fracture and hence the foregoing masses may be repeated; *G*, Goose river.

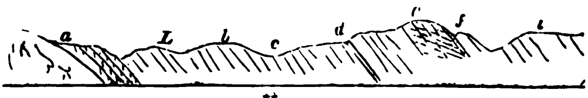
The rocks at Camden are identical with those of Berkshire. Their order of arrangement the same. All the differences arise from their having been changed by their vicinity to trap and granite, as in the slates macles are partially developed. This section has one advantage over the Berkshire section, as it evidently gives us the rocks according to their succession. Their aggregate thickness I estimate at 2,000 feet. Conglomerates occur in the mass at K. The Taconic rocks extend from Camden seaward. They appear and form the Fox islands 12 miles from Camden; where they are much changed by igneous rocks at certain points, especially where they are traversed by dykes.

At Thomaston, seven miles distant, the slates and limestone similar to those of Camden are the prevalent rocks. The limestone is traversed by a huge trap dyke.

§ 21. In Rhode Island near Smithfield, quartz, slate and limestone are well known.

The succession here is as follows, and is represented by fig. 4. The rocks lie in a trough bounded on one side by granite and on the other by a conglomerate of the carboniferous system.

Fig. 4.



g, granite; *a*, altered magnesian slate; *L*, *c*, *e*, limestone *b* and *d*, dykes, in the form of hornblende; *f*, slate partially changed to serpentine; *V*, valley of the Blackstone; *i*, granular quartz interlaminated with talcose slate; on the right of the section, the coal conglomerates occur in juxtaposition.

In this section the older rocks seem to rest on the newer. The section is made out so far that we can only speak of the masses which represent it. The succession is obscured by drift and intruded rocks. In general, I may observe that the quartz, limestone and slate resemble the rocks of Berkshire.

It is important that the student should be acquainted with certain phenomena respecting the members of the Taconic system, which obscure their relations at many places. One of these phenomena is produced by the intrusion of pyrocrystalline rocks, granite or sienite. These intruded masses separate the members of the system from each other, and at the same time change the direction of dip. This fact is illustrated in a belt of country near Fisk kill at the Rocky Glen factory.

Fig. 5.

Thus *a*, magnesian slate; *c*, limestone; *b*, e, granite, which separates these two members from each by a rocky ridge.

It happens, however, that ridges of mica slate are interposed in the same manner. Probably the deposit was originally thin, and hence has been worn away by diluvial action. Some five or six miles sometimes intervene between two members of the system, as in Cherokee county, N. C., where a mica slate like that of New England with staurotides intervenes between the quartz and talcose or magnesian slate. This subject may be reverted to again.

THE TACONIC SYSTEM IN THE SOUTHERN STATES.

§ 22. The lower Taconic system is equally well developed in the southern as in the New England states. From the northern part of New England it is prolonged southwards, and upon the line of prolongation it continues uninterruptedly for more than one thousand miles. For the purpose of illustrating its development in the southern states, I have selected the region of the Warm springs, in Buncombe county, North Carolina. The series at this place with their sequence is illustrated by fig. 6.

It is situated in the midst of a cluster of rough mountains, along the bases of which flows the French Broad river. In some respects it is admirably adapted to geological investigations; in others it has its objections, the surface or slopes of the mountains are too rough to be traversed where great accuracy is required.

The succession of the rocks however is determined without much labor, especially the inferior masses, those which are under consideration. So also their relations to the primary rocks upon which they repose. The latter I regard as an important consideration at this time, inasmuch as it seems necessary to determine them in order to remove certain objections to my views which have been started since the publication of my report upon this system.

We find at this locality an anticlinal which clearly separates the pyrocrystalline rocks from the base of the Taconic system. It is not a local disturbance nor confind to an area of a few hundred yards. The older masses, consisting of gneiss, mica slate and hornblende, dip generally S. E. from Ashville to the Warm spring, or indeed from the Blue ridge itself. The Taconic rocks on the contrary dip westward for fifteen to twenty miles, though in the Paint mountain range there are numerous changes of dip. In fine, the locality at the Warm springs is a good exhibition of the development of the lower Taconic rocks in the southern states.

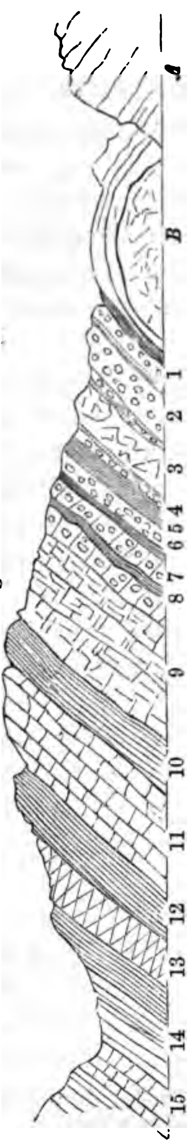


Fig. 6.

B, Sienitic granite, which in consequence of its protrusion at a period subsequent to the deposition of the lower rocks of the system, throws them into an arch.

1, talcose slates and slates with pebbles; 2, seamy ferruginous sandstone, 115 feet thick; 5, slaty conglomerate and slaty sandstone; 6, vitrified quartz of a brownish color, 200 feet. It contains pebbles and frequently fragments of slate. 7, brown silicious slate passing into quartz with a few pebbles, 85 feet; 8, granular quartz; 9, talcose slate, 200 feet; 10, quartz, the two beds with the slate included is 1500 feet; 11, slate, 250; 12, gray limestone, 500 feet; 13, gray fine grained talcose slate, over 150 feet thick; the mass is too much concealed to admit of its exact measurement. Adjacent to this mass I find a feldspathic slaty sandstone of an undetermined thickness, and its relations are obscurely developed.

The foregoing statement respecting the thickness of the masses at the Warm springs, is as near their actual thickness as the exceeding rough and steep surface of the mountain will permit. The united thickness of all the masses is therefore about 3000 feet. The sequence of the rocks is exact. The dip of the superior masses is west, that is from the axis of the primary schists A, adjoining them on the east; and I may here remark, that the line of demarkation between the former and latter rocks is well defined. The dip of the inferior rocks is north of west according to their distance from the axis of elevation.

The rocks at the Warm springs when compared with those of Berkshire county, embrace a larger development of quartz than of slates, and the beds of conglomerate are more remarkable, extending far up in the series; but the slates and quartz, lithologically, are undistinguishable from those of Berkshire. The masses are widely separated and are unquestionably correlative; besides, we have the evidence of continuity of *rock*, that same clear well defined separation from the rocks of the Blue ridge that we find both at Williamstown and the Warm springs of Buncombe. When we go farther and compare the subordinate masses we find that the same resemblance and identity holds good; for example, the limonites and manganese, the ferruginous quartz, both yellow and red, chert, agate, etc., are common to the whole belt of which I am speaking.

§ 24 In Cherokee county, N. C., all the members are present which I have given as belonging to the formation at the Warm springs, but the system is separated a few miles by the interposition of a ridge of primary schists with staurotide. Conglomerates occur three miles northwest of Murphy, Cherokee county, which dip eastward, to which a series of slates and quartz rock and limestone succeed, accompanied with beds of limonite, as in Berkshire, Mass. To the westward of the conglomerate, the ridge of primary schists come in, after which the dark colored slates and brecciated conglomerates and sandstones, &c., occur as in Columbia, Rensselaer and Washington counties, in New York, and as they recur at the Paint rock in Tennessee, six to ten miles west of the Warm spring in Buncombe county, N. C. Although there is a separation of the older Taconic rocks from the newer by the primary rocks to which I have alluded, still, there is no question as to the relationship which exists between them. I find a similar separation in New York by the intrusion of granite. The intrusion of granite is a phenomenon which is not likely to lead to error. In the recurrence, however, of the primary rocks, particularly the fine mica and talcose slates, the geologist might regard them as interlaminated masses, but a careful examination of relations of these rocks to each other will result in the conviction that the primary rocks are underlying and older masses, and have no connection with the sedimentary rocks which they geographically separate.

§ 25. The cluster of mountains which the French Broad river has cut through at the Warm springs is prolonged northwards and southwards. The range is necessarily crossed in going from Ash county, N. C., to Abingdon, Va. Stone mountain which rises near this route is quartz, the base of the system. It is succeeded by slates and limestones, and conglomerates and sandstones, in the order which I have already stated in sufficient detail. The limestone, however, is not a marble as in Massachusetts and Vermont, except at a locality about half way between Taylorsville, in Tenn., and Abingdon, Va. It is here a white marble, and is evidently an altered mass. The change is quite local and has taken place on a line of disturbance, and where the rocks are contorted and wrinkled. The route follows a rapid river, known as the Laurel. This range has received different names at different places. Between Macon county, N. C., and Tennessee, it is called Iron or Smoky mountain; between Cherokee county and Tennessee, it is known as the Unaka mountain; between Yancey county and the same state it is Bald mountain. From the northwest corner of North Carolina to Cherokee, quartz rock is the predominant rock of the range. It is traversed in the line of North Carolina and Tennessee by the Watauga, the Nolachuky, French Broad, Pigeon, Tennessee and Hiwassee. All of these rivers cross the line of base of this system of rocks and furnish fine sections and exposures of it. The conglomerates and quartz, however, in Cherokee county, are upon a belt eastward of the mountain range, while further north of this hard rocks form their crests and the highest points upon their ridges.

§ 26. *Sections of the lower Taconic rocks in Virginia.* — Another section a little further north is opened along the course of New river, which rises in North Carolina and flows northwestward into Virginia. I examined this section on a route lead-

ing from Hillsville to Wytheville, Va. I crossed the Blue ridge at the Fancy gap. The quartz rock and its slates and conglomerates will be crossed about fifteen miles east of Wytheville. It is sufficient to remark in this place that the rocks and their sequence differ in no respect essentially from those of the Warm springs in N. C. At an old iron furnace near the New river, the occurrence of the limestone is more abrupt than usual, the slate which intervenes between the quartz and limestone at other places is wanting at this, and the limestone, in consequence of the inclination of the quartz, seems at the surface to dip beneath it. It is not, however, an underlying mass.

The limestone is gray, and only semicrystalline. It is overlaid by a dark colored slate. On this line of section, the rocks which succeed still further on the route to Wytheville, will be given in detail in the proper place. Thus far, the section corresponds with those I have already given.

§ 27. The next section is represented by the annexed cut, fig. 7. It leads from Waynesboro to Staunton, Va. Beginning at the western base of the Blue ridge, the series consists of, 1, Talcose slates accompanied with seams of iron breccia, seventy-five feet; 2, green talcose slate with breccia thirty-four feet; 3, quartz and iron breccia, twenty-five feet; 4, green thick bedded slate, seventy-five feet; 5, thin bedded quartz and iron breccia, alternating also with slate and quartz in beds presenting a ribbon-like appearance, 100 feet; 6, talcose slate, 100 feet; 7, quartz and iron breccia, 400 feet; 8, reddish and purplish slates and two or three beds of quartz; 9, thin bedded quartz; 10, of white and gray vitreous quartz, 500 feet; 11, talcose slate or light colored magnesian slate, too much concealed under debris to admit of a determination of thickness; 12, gray limestone, 300 feet; 13, black and gray slate with beds of shaly limestone.

In this section the recurrence of the iron breccia is the most remarkable feature. There is less quartz than at the Warm springs or at the Stone mountain. Still there is a great similarity in the group with those at distant points along this remarkable range.

§ 28. It remains now to describe the Harper's ferry section, which runs along the eastern slope of the Blue ridge with a southeasterly dip instead of the western slope. The Potomac crosses the base of the Blue ridge at this place. The rocks are finely exposed and the succession can not be questioned. Neither can the relations of the sedimentary rocks be misunderstood. The steep mountain which rises from the river on its north side, exhibits very clearly at a distance the line of demarkation between the primary and Taconic rocks; and on a near approach to this line, we find it is produced by the difference of the rocks. The primary and underlying rock is a wrinkled talcose slate, similar to the New England slates and Green mountain slates of the same name, and which are associated with gneiss and hornblende. 2, a brecciated conglomerate, eight feet thick. This rock makes the narrow belt on the south face of the mountain, and causes the distinct line of demarkation between the older and newer rocks. 3, greenish and purplish slates containing brecciated quartz, 500 feet; 4, slates, three to 400 feet; 5, purplish quartz, two feet; 6 slate, two feet; 7, breccia, four feet; 8, clear and vitreous quartz, seventy feet; 9, purplish slates, traversed by numerous seams of milky quartz, sixty feet; 10, quartz, thin bedded below, and thick above, 200 feet; 11, slaty quartz; 12, hard contorted quartz. Slates with limestone succeed the foregoing, the latter crops out from beneath the Trias, at a point upon the Potomac, from which were taken the brecciated pillars which ornament the halls of the capitol at Washington. The rocks eastward of Harper's ferry, however, are too much concealed on the line of rail road to enable me to give their arrangement in detail, still, enough is exposed to warrant me in speaking confidently of their sequence which as I have already intimated, does not diffe r materialy from those of the localities which I have already given. In the minor details there are certain unimportant differences particularly in regard to the thickness and position of the brecciated conglomerates and a few intercalated beds of slate and quartz. The former are noticed for the purpose of proving the sedimentary origin of these rocks, an origin which many geologists would formerly have questioned, and even at this day were it not for their presence.

The quartz and slates still continue, and these are succeeded by a gray limestone, which crops out from beneath the Triassic, or as some regard it, the Liassic system east of the locality which furnish the Potomac marble.

§ 29. From Harper's ferry the series continues through Pennsylvania into New York, and then into Massachusetts and Vermont, retaining the same relation to the primary rocks throughout its long extended line. If we trace the relations of the quartz rock to the Blue ridge and Green mountains of Vermont, we find it varies exceedingly along this great range. In North Carolina, the quartz rock at the base of the Taconic system forms independent ranges of mountains sixty or seventy miles to the west of it. As the quartz extends northeastward, the Blue ridge and the quartz approach each other. At Waynesboro the quartz reposes upon its western face. At Harper's ferry the quartz reposes upon its eastern face, having crossed the Blue ridge in its northern prolongation. The rocks which compose the Blue ridge in North Carolina and the southern part of Virginia, diverge from it south of Charlotteville and strike towards Baltimore. If the Green mountains and Hoosick mountain of Massachusetts, are regarded as a prolongation of the Blue ridge, we again find the quartz and slates at the base of the system reposing upon its western flank, though here these rocks form of themselves a distinct and independent range, which has long been known as the Taconic* mountains. I have already spoken of the wide distinction there is between the system of rocks composing the Green mountains and those of

* The word has been spelled Taughconnac and Taghconic, but those modes of spelling have given way to Taconic.

the Taconic system. When we trace however the relations of these masses throughout the entire extent of the country, the importance of regarding this distinction as established can scarcely be doubted. If we assume that the Green mountains are composed of the altered Hudson river slates, the same assumption must be made respecting the whole of the Blue ridge. The only belt where the Blue ridge is composed of rocks which can be regarded as metamorphic, is at the crossing near Waynesboro. At Charlotteville and westward towards the Blue ridge, gneiss, mica slate, hornblende and sienites, prevail. But near the ridge, a sedimentary rock which occurs extensively in North Carolina, comes in; and I found in crossing the ridge, that the green slaty rocks were charged with epidote, with scarcely a mass of gneiss or hornblende which could be recognized. I can only say, that the Blue ridge for a short distance exhibits a different composition, while at the same time the Taconic system, which appears on its western flank, is quite as clear and distinct as at any other point on the line of this great belt.

THE TACONIC SYSTEM ON THE EAST SIDE OF THE BLUE RIDGE.

§ 30. The account which I have given of the lower Taconic rocks, relates to the series which flank the Blue ridge on the west. I shall now describe a parallel series which skirt the same range on the east, and which though not equally continuous with the former is still the predominant system over a wide belt of country, extending in a northeasterly and southwesterly course from South Carolina to Maine. The Taconic rocks which I propose to describe in this connection, are destitute of that regularity and symmetry which mark those upon the west side of the mountain. The series also is incomplete, I find the upper members are wanting, and in placing this series in the Taconic system, I am guided by lithological characters.

§ 31. *Members of the series.* These embrace conglomerates, quartz rock and quartzite,* talcose, chloritic and argillaceous slates.

The mode in which the foregoing rocks are arranged, will be understood by describing them as they occur upon a transverse section. If we descend the eastern slope of the Blue ridge in North Carolina, in the direction of Wilkes county, the series which represents the geology of the country traversed consists mainly of mica slate and gneiss and intruded granitic masses. I believe they resemble the New England rocks of the same name as perfectly as possible. These continue upon its flanks until after we pass a low range called the little Brushy mountain, which traverses the country about ten miles east of Wilkesboro, in a N. E. and S. W. direction. This formation continues to a point about one and a half or two miles east of Lexington, Davidson county, N. C. At this point and in a line ranging with it nearly N. E. and S. W. the system changes, the primary giving place to a series of sedimentary masses which continue to a line about ten miles west of Raleigh, in Wake county; it comprehends a belt of country about seventy miles wide. This belt is prolonged, in the direction I have stated, into Virginia and South Carolina. It is necessary, however, to state, that the lines of demarkation of its borders are not equally well defined at all points, but they are usually recognizable by making offsets at short distances to the right or left.

The prevailing dip of the rocks of the Blue ridge is S. E. When, however, we have passed from the pyrocrystalline rocks to the Taconic system, the dips are changed, first to the S. W. and finally to N. W., which is the prevailing dip. The angle dip varies from 40° to vertical. The first mass which indicates a change in the series of rocks, occurs a mile or two east of Lexington. It is a coarse talcose mass. Farther on it becomes

* The term quartzite I use to designate a kind of silicious mass which closely resembles chert or hornstone associated with many of our limestones.

a fine talcose slate which soon becomes silicious and forms a tough mass, which I shall denominate a coarse talcose quartzite. Its color is light green, it is often obscurely porphyritic, and though jointed, it is one of the most tough rocks which is ever encountered by the geologist or miner. When moderately silicious, it decomposes readily and forms a deep red soil. As it is nearly vertical and as it weathers unequally, the outcrop presents a singular succession of sharp edged masses, which are rounded in the direction of the strike. It presents an interrupted succession of hatchet shaped eminences. These are sometimes seven or eight feet high and ten feet at the base, and it sometimes also happens that two of these projecting masses stand within a few feet of each other, and hence are conveniently roofed over for a small outhouse, the rocks forming the two parallel walls. These projections are so numerous on the Three Hat mountain, some eight miles east of Lexington, that its surface can not be cultivated. The rock between Lexington and Spencer postoffice is mostly quartzite, with bands of flinty slate which breaks with a smooth conchoidal fracture, and a soft even bedded talcose and chloritic slates. It is difficult to assign a satisfactory reason for the occurrence of the quartzites in the midst of the unaltered slates. The change does not appear to be due to the proximity of trap or igneous masses. I have therefore for want of better reason regarded these cherty masses as products of chemical forces acting at the time of their deposition. The quartzite of North Carolina is so peculiar that I deem it useful to describe it still more particularly. In the extreme variety it is a pure bluish hornstone, and breaks with a flat conchoidal fracture. In this form, it is rather easily broken, but when less pure, it is tough; the fracture is then uneven as if the masses were torn apart. It is translucent on the edges, which are sharp like flint. When struck it is often sonorous like cast iron. It is not perfectly homogeneous as a mass, as small crystals of feldspar and sulphuret of iron are often disseminated through it. In disintegrating, the outside weathers to a drab. In Chatham, Randolph and Davidson counties, it never forms ledges of jointed rocks, but crops out in the manner I have just represented. Its strike is N. 25° E. while the ridges which it traverses, and which are narrow, run N. 10° E. The ridges are quartzite, the valleys are usually underlaid with a soft slate. The quartzite in many instances is massive, but passes into jointed silicious slates. The latter are frequently associated with novaculite and other fine and coarse grits. Numerous varieties of quartzite are met with, as the blue and purple, light gray and green of many shades, and composed of impalpable individuals, also yellowish and yellowish brown, and traversed by seams of quartz; or deep green and banded varieties, or coarsely agatized ones. The quartzite is constantly undergoing decomposition. The atmospheric influence penetrates deeply into the rock; and its extent is marked by an opaque white friable border, &c. &c. Indeed all the varieties of quartzite disintegrate, decompose, some slowly and others rapidly, the silicious and ferruginous varieties forming a deep red, and the apparently pure silicious ones, a pale drab colored soil. These belts of quartzite are frequently half a mile wide, in which a few beds only of slate occur. The most interesting localities are in Davidson and Chatham counties. They are not confined however to these counties.

Randolph county, which succeeds Davidson on the east, furnishes a large amount of quartzite in its rocks. All the ridges may be set down as formed of this kind of rock, excepting those which belong to a narrow belt of sienite which comes in about six miles west of Ashboro. Fine and coarseish grits resembling certain varieties of novaculite are frequently met with in and about Ashboro. But at Franklinville, eight miles east, the green chloritic slates predominate with only a few beds of quartzite. The soft green slates are traversed by veins of milky quartz, but they are rarely auriferous. A few miles further east the slates are replaced by a thick bedded chloritic sandstone which bears a trappean appearance, and as it weathers readily the detached masses become round. These thick bedded rocks are again succeeded by thin bedded, which contain pebbles of quartz. Such masses are repeated frequently in the distance of twenty miles. Deep green slates, rather thick bedded chloritic sandstones and beds of brecciated conglomerates belong to the same belt. Twenty miles west of Pittsboro or about twelve miles east of Franklinville a belt of this brecciated rock may be observed near by and crossing the road. At Pittsboro, red and purple slates with breccia prevail, particularly near the village. At Jones' falls, on the Deep river, the quartzite and brecciated quartzite and porphyries form a belt half of a mile wide and extend some five or six miles in a northeast direction. The porphyries are no doubt products formed by the adjacent trap of the neigborhood, as the Taconic rocks emerge here from beneath the sandstone of the Trassic or Permian system.

The belt of Taconic rocks which lie between Lexington on the West and Deep river at Jones' falls on the east, passes up through the east part of Guilford county, form most of Alamance and Orange counties, and so onward through Granville into Virginia. At Hillsboro, Orange county, a range of hills come down from Granville county. These hills are frequently composed of quartz and iron breccia; and in the northwest part of Granville county, an extensive range of slate conglomerate occurs, which has been traced to the Dan river in Virginia, and south some ten miles. This bed of conglomerates has a very steep dip from 60° to 65° and occupies a belt at at least one fourth of a mile wide. From the northwest corner of Granville county, the Taconic rocks extend nearly to Roxboro, when they are discontinued and replaced by a tabular granite.

This belt in North and South Carolina consists of quartz which is developed only upon a limited scale, but which is accompanied by the iron breccia as in Berkshire county, Mass., talcose, chloritic and argillaceous slates. The first is undistinguishable from those of Vermont and Massachusetts, which occupy the same geological position; slate conglomerates as in Granville county, and extending into Virginia; quartzite which is far more abundant among the slates than in Massachusetts.

Beds and ranges of argillaceous slates of various colors seem to be distributed without much order; or in other words it is impossible to trace them far in the direction of their strike. Another range of the Taconic slates passes through Johnson county. It is exposed near Smithfield. In range of this belt, a similar rock crops out near Gaston, and appears three or four times on the road to Weldon. The Johnson slate is separated from the slates and conglomerates of Orange and Granville, by a strong belt of primary rocks, among which granite is the most conspicuous member. It overlies, I believe, the hornblende and gneiss and mica slate rocks, and in this respect is similar to the Maine granites; it appears to have been ejected through fissures and to have overflowed the primary schists. They are exposed as underlying masses at Warrenton in Warren county.

§ 32. It can not have escaped the reader that the limestones which are so important and prominent in the series on the western side of the Blue ridge and Hoosick and Green mountains is probably wanting in the series I have just described. In North Carolina I have not discovered it, and I have made only imperfect examinations in South Carolina on the line in which this series is prolonged. In Virginia there is a range of blue limestone at Gordonsville, but it scarcely passes further south. It appears to belong to the series I have just noticed in North Carolina.

At Gordonsville there are soft talcose slates reddish white, and in connection with it, or nearby, there are beds of slaty blue sparry limestone, dipping southeast. Westward of Gordonsville the rock is argillaceous. In this connection the purple, red and green roofing slates come in. They are similar to the slates of Maine, which contain the nereites. They are the prolonged beds of roofing slate of Chatham county, N. C. With the latter, thick seamy beds of conglomerates occur. The roofing slates, west of Gordonsville, Albemarle county, are succeeded by thick, heavy beds of green chloritic slates, and alternate with them; they are seven miles east of Charlottesville. These beds, as we approach Charlottesville become more and more like the corresponding formation at Franklinville, Randolph county, N. C.

One mile east of Charlottesville, near the bridge, the slates and thick bedded chloritic masses have been altered by heat, having become hard and epidotic, accompanied with a few seams of asbestus. So also in a cut for the rail road near by, I found thin seams of specular iron. The rock is also cut up by seams of milky quartz. When the rock is unaltered, it is soft, green and resembles the rocks of Randolph and Chatham county, N. C., which are associated with conglomerates. They also decompose and form a deep red soil. These Taconic rocks are interrupted at Charlottesville, at the university, by sienites which are protruded among the slates near their junction with the primary rocks which now come in and succeeds them on the west. I saw indications of conglomerates in the vicinity, but none in place; but the whole formation between Gordonsville and Charlottesville is almost identical with that of Randolph and Chatham counties, in N. C.

§ 32. It is difficult to describe in a satisfactory manner the unfinished series of the Taconic rocks in the southern states. They are widely spread out, but as they have disintegrated and the debris remains in place, it is impossible to make out the succession as it really is. It has therefore been described as a wide belt consisting of a few members only, and as extending northeastwardly and southwestwardly, and dipping generally to the northwest at a steep angle. That these rocks are all sediments seems to be established by the relations they hold to conglomerates and brecciated conglomerates. This series represents the lower Taconic rocks if lithological characters may be relied upon. No carboniferous or black slates appear in the series in South or North Carolina, or in Virginia.

§ 33. Another remark seems to be called for, viz: that the North Carolina series belongs to those isolated fields of Taconic rocks which occur in Rhode Island and Maine. They occupy the same relations to the principal mountain chain which traverse the country from the northeast to the southwest.

I have stated that this belt of rocks is prolonged from North Carolina into Virginia. An interesting locality within the state last named, for illustrating the changes which rocks have sometimes undergone through the agency of heat, may be witnessed at the rail road crossing leading from Charlottesville to Staunton. On the east side, and upon the flanks of the Blue ridge the chloritic slates seem to have become massive, accompanied also with the development of epidote in nests and geodes; and indeed masses seem to be semi-epidotic throughout. But I did not observe at this crossing, the primary schists, gneiss, mica and talcose slates, or well developed hornblende rocks. If I was disposed to assume that the rocks of the Blue ridge were only the altered rocks of the lower Silurian or Hudson river, for example, I would refer the reader to this locality for proof. But the character of the Blue ridge and that of the Green mountains of Vermont, can not be changed by such local phenomena; and it seems to me a waste of words to state the facts which refute an assumption so palpably erroneous as that respecting the rocks of the Green mountain range. I refer to the assumption that the Green mountains are composed of the altered masses, which are known as the Hudson river rocks. But I may present here another view which discredits this assumption, it is that which recognizes in the Taconic system the source from which its materials have been derived; such is the similarity of the coarse particles of the quartz, and its conglomerate, gneiss and mica slate, that we are not left in doubt a moment respecting their origin; we may trace the materials to the parent rock, and this parent rock is a constituent part and member of the Green mountain range, a preexisting series which have furnished the debris from which the Taconic system has been constructed. From this fact it follows, that in whatever light we may view the Taconic system, either as an independent system or as an altered series of the age of the Hudson river group, the Green mountain rocks themselves, can not be regarded as of the age of the latter. Neither is there any evidence, any monuments, or phenomena which will justify the assumption, that the gneiss, mica and talcose slates and hornblende of the Green and Hoosick mountains were ever sediments at all. Although I have not stated all the facts respecting the lower series of Taconic rocks in the foregoing pages, still the limits within which I propose to restrict myself will not allow of further details. I have shown in numerous sections that the sequence of the members of this part of the system differ materialy from the lower Silurian, and that the difference can not have arisen from a local accident or occurrence as we are accustomed to regard a few local changes, but must be due to general facts, such as prevail from Maine to Georgia; and as the lower Silurian lies along a belt nearly parallel with the Taconic system, and still the members of this system differ so much from each other, I feel justified in the opinion that these systems are unlike and differ in age, and can not be brought into correlation. It is not metamorphism which causes this difference; metamorphism has nothing to do with sequence. It is not by intercalated beds that the Taconic system exceeds in thickness the Silurian. It is not to metamorphism that we are to attribute the general absence of fossils, for a large proportion of the rocks are not metamorphic. Those who maintain then that the Taconic system is identical with the Silurian, are bound to show how these important differences are to be reconciled. They are not due to an inverted axis and if not due to one or the other of the causes I have named, it follows that the distinctions are essential and not accidental, and we are required to consider the systems themselves as different systems.*

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* Since the foregoing was written I have observed that Mr. Hall assumes that the slates of Maine in which the so called nereites occur, are either Carboniferous or Devonian.* As in the case of the assumption respecting the rocks of the Green mountains of Vermont, so in this it seems a waste of time to add facts to disprove a mere assumption. In this case, however, it may be well to inquire what fossils of this locality have ever been found of this age, and as the doctrine of metamorphism can not be adduced to sustain the assumption,

* Silliman's Journal, p. 434, vol. xix.

§ 34. *Roofing Slates.*—Roofing slates, if I rightly interpret the phenomena of the districts where they occur, are found both beneath and above the limestone which is marked 2 in sections 1 and 2. They can not however be restricted to these positions. But the beds which I propose to describe now, occupy those places.

The beds below this limestone, however, scarcely differ from those above. Of this I have satisfied myself after an examination of the slates taken from certain beds in Columbia county, N. Y., about three miles south of East Canaan. Their characters scarcely differ from those of Hoosick in Rensselaer county, belonging to beds which I believe are above this limestone. The Columbia slates are blue, green, or greenish and purple. They split evenly and appear hard and sound, and sufficiently firm to resist the action of the weather.

The beds may be observed in the road between East Canaan and the state line. The quarries are not opened on this road, but just beneath the limestone, fine blue fissile slate occurs in thick beds. I regard these beds as older than those which have been opened at Hoosick. There can be no doubt of the relations which the Columbia slates bear to the limestone I have referred to, but I am unable to state the thickness of these beds in consequence of their concealment under drift.

From the view which I have taken of the relations of the lower Taconic rocks, it follows that the slates beneath the limestones have increased in thickness in their westward extension. These are also finer and much more even bedded, and contain but little quartz either in dissemination, in grains,

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and as there are no fossils belonging to either of the systems, it must be erroneous. The most delicate imprints are preserved in the slates of Waterville, and here the coarse and prominent fossils of the Devonian or Carboniferous should be found, besides, there is not the least resemblance to the Devonian in mineralogical characters; but the rocks of this system of slates resemble the rocks which occupy the same position in Rensselaer and Washington counties, in New York, as well as the slates which extend through the southern states.

or bunches. Sulphuret of iron in fine particles is often present, and destroys the slate sooner or later by its decomposition.

§ 35. The beds of roofing slate and which are situated above the limestones, are the best known at the Hoosick quarries. They have been extensively opened at Hoosick Four Corners and at North Hoosick. The slates are blue, fine grained and even bedded. At North Hoosick, slates of a suitable thickness for roofing have been obtained five feet long and two feet wide. One surface of the slab was as perfect as could have been made with a plane.

The dip of the rock is east 20° south. The angle of dip 45°. There are local variations, both as to the direction and angle of dip.

The most interesting fact respecting the Hoosick slate is, that they contain fossils, and so far as discoveries have as yet been made, they are the lowest and oldest rocks in which fossils occur in this system.

A difference of opinion existed at one time, respecting the class to which they belonged; from their close resemblance in texture to fucoids in the flags and slates of Washington county, they were regarded as vegetables. I still entertain doubts upon the question, but as it seems to be generally conceded that they are animals, belonging to the family of graptolites, I am disposed to concur in that opinion.

As in the lower roofing slates so in these it is difficult to determine their thickness. It is evident that a dislocation exists at Hoosick falls, three miles northwest of the quarries. This dislocation pursues a route which leaves the quarries, about half a mile in a straight line, to the eastward. The first quarries which were opened, were near this line of dislocation at a place on the west side of the Hoosick at the bridge. Westward, the slate forms the base of the hill. Going east however from the old quarry at the bridge of which I have spoken, the series of beds is unbroken. A good section may be obtained by following up a small stream about half a mile southwest from Hoosick falls which runs down the slope of the hill, where the quarries are opened. This stream lays the rock bare at many places, disclosing a uniform dip and a regular succession of beds. The same mass of slate extends at least a mile in a direct line east from the quarries, passing over a wide ridge, at the base of which it is probable there is another dislocation. The next ridge east is still slate. But if the estimate of thickness is based upon that part of the series which forms the ridge spoken of, the entire mass is 5000 feet thick. The lower part of this mass is silicious, and coarse, and resembles the rock which overlies the limestone near the state line. It soon becomes softer, finer grained, in the ascending series of beds. But as a whole it is a roofing slate and I have not been able to discover those bεds of sandstone which resemble those so common in the higher part of the series. The slates therefore form a mass which are properly worthy of a distinct notice; and, as they contain the oldest fossil known, they become still more interesting as a series of beds.

The graptolites are confined to a limited space. In this respect they agree with all fossils belonging to the oldest series of rocks.

There are probably two species, but as the impressions they have left are obscure, I have figured but one, selecting that whose characters are preserved the best.

§ 36. Roofing slates extend southwards through Pennsylvania, Virginia and North Carolina. Those of Albemarle county in Va., are fissile and generally blue, but purple and red beds occur. In Chatham county in N. C., upon Rocky river, light green slates are abundant which split in very thin lamina on being heated. Six miles north of the Gulf, Chatham county, fine purple slates have been discovered, but as there is a covering of soil it is difficult to determine whether they are of any value commercially. Geologically they show the persistence of the rock. It should be stated that those of Albemarle county, Va., and Chatham, N. C., are upon the east side of the Blue ridge. They probably belong to the oldest beds, or those which lie beneath the limestone. In North Carolina, I have been unable to determine their relations to the limestone, as it does not exist on the east side of the Blue ridge. They occupy a position which proves their sedimentary origin, inasmuch as they are not removed very far from beds of conglomerate.

ABSENCE OF CARBON AND ABSENCE OF FOSSILS IN THE LOWER TACONIC ROCKS, ETC.

§ 37, The absence of fossils in the lower Taconic rocks excepting in the Hoosick slates, has been attributed to the changes which they have undergone by the agency of heat. This doctrine, however, should not be adopted without an examination of its claims to our belief.

If the relations of limestone of Berkshire are carefully examined it will be found that they were deposited upon sediments beneath some 1000 feet thick. The question then comes up, is it probable that sufficient caloric could have penetrated through this thick mass of different rocks varying considerably in their conducting power to have given the particles of carbonate of lime that mobility so necessary to their crystallization—for it must be conceded that it is only through this thick series of rocks that heat could have affected the limestone, since porphyries, trap, or pyroplastic rocks are wanting through the Taconic range. Not only are the traps rare in this range but dykes of injected rocks are rare in a large part of the Hoosick mountain range.

If we turn our attention to the slates, they appear to be formed of materials scarcely differing in the condition they were before consolidation had taken place. If the breccias and conglomerates are examined their fragments are still like those of the parent rock.

When the color and grain of the Berkshire marble is compared with that of the Trenton limestone in the southwestern part of Virginia, the color as white and the crystallization is nearly as perfect in the latter as the former, and yet the fossils are preserved in the latter with all the distinctness and perfection that they are at Trenton falls in N. Y. Crystallization does not obliterate fossils.

I infer from the foregoing facts that there is little probability that animals and plants existed at the time the Berkshire limestone was deposited.

At this period there seems to be an absence of carbon. The dark color of the limestones of Berkshire is due to the slates or else to sulphuret of iron, and besides the uncrystallized gray limestones of southwestern Virginia and Tennessee are as destitute of fossils as the Berkshire marbles.

Again I remark that it follows, that the absence of fossils is due to the period and not the condition of the rocks; and hence too, it follows on palæontological grounds the Taconic system is distinct from the Silurian. It may be laid down as a principle in geology that in all countries the formations are to be worked out and determined on evidences furnished by each country respectively. American geologists will not try their formations exclusively by those of England or Russia.

ORIGINAL POSITION AND VARIABLE THICKNESS AND EXTENT OF THE MEMBERS COMPOSING THE TACONIC SYSTEM. LONG PERIOD OF REPOSE DURING WHICH THE MEMBERS WERE DEPOSITED, ETC.

§ 38. That the present condition and relations of the members of the Taconic system may be understood and made intelligible to the student, I have presented in a diagram the original position of the members of the series as they were probably deposited. It is designed to illustrate also the facts respecting the variable thickness of the members of the series at different places and their discontinuance in consequence of thinning out, and the limited area over which some of them were expanded, and the probable fact that the plane of deposit was subject to oscillations, or an upward movement in consequence of which the superior rocks would not be extended far enough towards the base of the system as to cover or overlie the oldest members of the series, their outer margins would be confined within the outer rim of the basin.

Of all the members of the series, it is probable the conglomerates and quartz rocks are the most limited, or confined to the smallest, and the slates and limestones are the most expanded or spread out over the largest areas.

In the Taconic system we have the usual evidence of a long period of repose during which the rocks were formed, for although these may have been feeble upward movements as stated in the foregoing paragraph, still the evidence seems to be that disturbances of the soil were scarcely greater than during the period when the Silurian rocks were deposited.

Towards the close however of the Taconic period, we have abundant evidence of a change in the condition of the surface, for we find brecciated conglomerates among the upper members of the series, and besides at many points where the junction of the lower Silurian and Taconic rocks are exposed, we may observe that the beds of the latter are inclined, or had undergone a change of position prior to the deposition of the former. When they received their present steep southeasterly dips is not easily determined, but that it was just prior to and during the lower Silurian period is probable from the fact that the outliers of this system were not expanded over the lower beds of the Taconic system in consequence as it would seem of the elevation which the surface had undergone. In confirmation of these views I shall show that this period was one which was marked by numerous fractures and the intrusions of trap and metallic veins.

But leaving for the present the consideration respecting the period when the rocks of the Taconic system received their present dip and position, I may observe that as a general fact they dip towards the southeast at an angle varying from 20° to 45°, and even frequently they are much steeper. This inclination furnishes so few exceptions that it may be regarded as a general fact. In consequence of this fact we are obliged to offer some explanation which shall account satisfactorily for the apparent position by which the newer rocks appear to be older than those which lie at the base of the system.

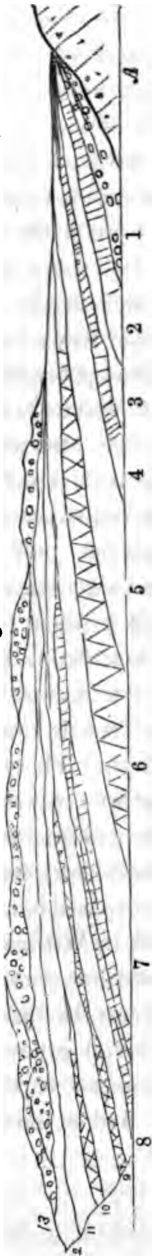

Fig. 8.

This explanation it appears to me is found in the numerous dislocations which are known to exist in the belt of country occupied by these rocks, and whose geographical position in New York, Massachusetts and Vermont, is upon the western slope of the Green mountains and which is bordered on the west by the Hudson river and Lake Champlain.* If we take our departure from the Hudson river and travel east or rather east 15° to 20° south we pass over the series at right angles to the direction of their dip, and if we take no notice of the dislocations which intervene between the river and the mountain range, our inference would be that we were passing from the older to the newer.

If we take notice however of the dislocations we shall find the series broken up into segments, each successive segment embracing a series older and below the one immediately west on the line of our section. In some instances it is true there is a repetition of rocks, and probably each segment always embraces members or parts of them which appear there in consequence of a repetition in two or more adjacent segments.

On reference first to figure 8, which represents the original position of the rocks of the Taconic system, we can readily conceive that a series of dislocations occurring at 2, 5, 7, and 8, would bring up all the members of the system. The dislocations through 6, 7, 8, would place the members of two segments in a position which would cause the newest member 13, of segment 8, to dip beneath segments 6, and 7, embracing the limestone and roofing slates already described.

* I am obliged to insert in this note, that I do not assume that the Hudson river or Lake Champlain are necessarily boundaries

This fact, however, may be better understood by reference to figure 1, where the present relations of these members 3, 2 and 4 are given. If this view is admitted, it exhibits a true succession when the series is taken in segments. Other views have been offered in explanation of the phenomena, and as I can not perceive in the geological statics of the region reasons for adopting a different interpretation of facts, I prefer the one I have given, as it appears the most simple. It is important to observe in this connection that the force which breaks the continuity of the strata, exerts its maximum power nearest the mountain chain; and hence, it may be regarded as proceeding outward from it; and hence, too, the frequency of fractures the nearer the rocks are to the mountain chain. This statement appears to be sustained by the Williamstown section, figure 1, where, in the space of two miles, no less than 5 distinct and well defined fractures or dislocations may be observed.

So in section 2, at the eastern base of Saddle mountain, and at its western base, this high range is interposed between two valleys; and about one mile from the dislocation, Stone hill breaks in upon the continuity of the valley, with a fracture on each side, which runs also along the base of the Taconic range which lies between Williamstown and Petersburgh. There is another class of phenomena which obscures the true explanation in cases similar to the one I have had under examination. There can be no doubt that hundreds of feet of solid rock have been removed by denudation, and certain rocks at exposed points have been entirely removed. Thus from Oak hill, in Williamstown, Berkshire county, the series is wanting in two or three members whose aggregate thickness is at least 2,000 feet; the quartz near the summit retains in perfect freshness diluvial grooves. It will be recollected that quartz which corresponds to this upper mass of Oak hill, crops out at the foot of Saddle moun-

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to the Taconic system. But that it disappears nearly on this line, is a fact. It is here that it meets with the thick and heavy beds of the lower Silurian, beneath which it is concealed.

tain, and heavy beds of slate and limestone overlie it. There can be no doubt, that those overlying slates and limestone overlaid also the quartz of Oak hill. If so, these masses have been removed. Members of the series, therefore, may be wanting at many places, and hence the true succession may not be made out.

§ 39 An inspection of figure (last referred to,) shows that the entire thickness of a series can not be made out at any given place, as some of the lower masses thin out before the upper are deposited above them. Hence we are unable to determine either the true succession or the upper members of the series at or near the base of the system. This is the case with the Taconic system, the members do not extend eastward to Hoosick mountain, and probably never extended so far eastward, and probably too the lower members which lie against Hoosick, or the Green mountain, do not extend as far as the valley of the Hudson.

The greatest obscurity in the succession of the rocks arises from dislocation and diluvial action combined, and this obscurity is the greatest at the junction of two rocks, whose lithological characters are alike. Thus the Taconic and Hudson river slates, meeting as they do, in the valley of the Hudson, perplexes almost all observers. The difficulty is increased in consequence of the mechanical effects which the dislocation has produced upon the adjacent rocks. All vestiges of fossils in the soft slates are destroyed by the crushing which the rocks have undergone, and hence it puts it out of our power to make out the line of demarkation at certain points between the two systems. The Taconic rocks in consequence of this disturbance are elevated higher along the margin of the Hudson, than the slates of the Hudson river group. Many geologists, in consequence of this fact, maintain that the former are the equivalents of this part of the Silurian system. I shall give most decisive evidence that this view is erroneous. I have offered the foregoing explanation respecting the phenomena, which are calculated to obscure the relations which subsist between the members of the Taconic system. It seemed proper to do this before I described the upper members of the system.

SUMMARY OF FACTS RESPECTING THE LOWER TACONIC ROCKS.

§ 40. 1. I have shown that the lower Taconic rocks, though once regarded as members of the primary series, are truly sediments, the beds of conglomerates giving and furnishing ample proof of the doctrine.

2. That the sediments are derived from the pyrocrystalline rocks, at least in part, from the debris of those which compose the Green mountains and the Blue ridge.

3. That they extend from Maine to Georgia, flanking continuously the ranges I have spoken of on the west side, or else forming distinct ranges by themselves. On the east side, the development of the members is ample, yet not so perfect as upon the west side, and moreover differ from them in certain lithological characters which show certain differences in the circumstances which attended their deposition. Slates predominate on the east side, and masses of chert are extremely common.

4. The relations and composition of the members prove that they are distinct from the Green mountain rocks on the one hand, and from the lower Silurian on the other. The quartz rock of Berkshire, of Buncombe and of Cherokee county, is not the Potsdam sandstone, nor are the marbles and limestones of Berkshire the lower limestones of the Silurian system, neither are the slates, either talcose, magnesian or roofing slates, shales and sandstones the equivalents, or corelatives of any rocks which are known to belong to that system. It has been shown that there is no similarity in kind, there is no similarity in sequence, and there is none in fossils to the lower Silurian system. None of the differences alluded to, can be explained by metamorphism, or inverted axes, or an inverted axis passing into a fault.

The result of all these showings is, that the Taconic system in its lower members, is independent of, and distinct from the Silurian.

5. It will be perceived that the foregoing conclusions are founded mainly on stratigraphical evidence. This evidence establishes a physical group which can not be brought in co-ordination with the lower Silurian group to which it has been compared. This group is mostly anterior to the organic period.

THE UPPER DIVISION OF THE TACONIC ROCKS. GENERAL CHARACTERISTICS OF THIS DIVISION. GEOGRAPHICAL POSITION. SUCCESSION OF THE MEMBERS. THEY FORM A SINGLE GROUP, ETC.

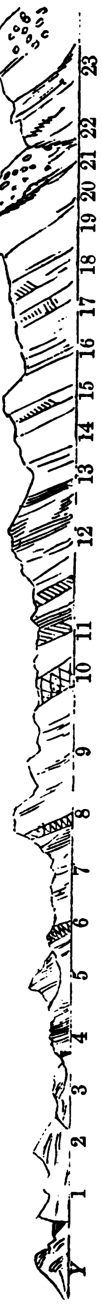
§ 40. The direct succession of the lower division having been determined, and their members having also been proved to belong to, and form by themselves a distinct physical group, I shall now proceed to state the general characteristics of the upper division. I have already shown that the lower rocks are represented by slates, and that they predominate so much over the quartz and limestones, that it might be regarded as a slate system. In the upper division, slates also appear in great force and are found in all the subordinate groups; yet, it can not be regarded as the predominant rock. The pure argillaceous slates, for example, never form thick beds without soon becoming silicious or calcareous, and perhaps both. Silicious slates and silicious bands and beds are every where interlaminated with those which are argillaceous; and besides the latter, the magnesian series seem to be wholly wanting, and are not represented at all.

The series begin on the west, where we find in the lowest beds black slates and black calcareous beds, as at Easton, Washington county, and St. Albans, Vt. The black slate is succeeded by silicious slates, interlaminated by thin beds of fine grained sandstone.

Ascending still higher, slates and sandstones continue in which also we find thin bedded blue limestones without fossils, succeeded by thicker beds of sandstone. Among the sandstones, those which contain carbonate of lime are quite prominent, and may be found in at least three beds; the thickest of which is over one hundred feet; gray sandstones, interlaminated with slate; thin bedded flags, with fucoids; cherty beds, green slates, one or more beds of vitreous quartz, coarse green slates, shales and grits; roofing slates, blue, green, purple and red; coarse sandstone and coarse shale passing into sandstone and conglomerates, and brecciated conglomerates. The latter terminate the series eastward, and geographically near the Hoosick roofing slates. In the foregoing brief enumeration in the ascending order, the rocks follow each other in a conformable position, and beginning with thin black slates, end in thick bedded sandstone and conglomerates. We find no where the marbles of the Taconic range or their representatives; the quartz rock, or its representatives; the magnesian or talcose rocks, or their representatives; and moreover, the Columbia and Rensselaer roofing slates are absent. Hence it follows that the groups must be lithologically, and when we take into the account the order of superposition, they must also be, in all respects, a different physical group. But if the dip and conformability governs the succession, we are obliged to regard the series as enormously thick, which with those who have not made the necessary examinations to form an opinion would be regarded as an objectionable feature. But the dip and conformability, however, should govern the succession, provided proper vigilance is used to avoid repetitions of the masses in the different segments of a section.

There are two modes of guarding against error of this kind. The first is, to become so well acquainted with the members of the series, that they can be recognized. The second is, to examine not only the cross section on the line of traverse, but to examine every mass which crops out in the direction of the strike where it may be concealed on the line of traverse, so that when the rocks are concealed in a cross section, they should be found and determined on the lines of strike: in other words the succession should be made out by an inspection of all

Fig. 9.



its members, some where near the line selected for examination. I can only say, that I have availed myself of all the means in my power to insure accuracy, and after examining many sectional lines, I am obliged to accept of the conclusion, that the series are enormously thick, and that it becomes necessary to regard the western rocks, as the oldest, or at the bottom, and, in consequence of this decision, the succession begins with the soft black slates and terminates eastward in the conglomerates and brecciated conglomerates in the neighborhood of the Taconic range.

§ 41. I propose to describe in the next place, in detail, the series as they are known in Rensselaer and Washington counties, N. Y., inasmuch as here they may be regarded as representatives of the division, and as types for comparison when it becomes necessary to speak of the same series in their prolongation to the southwest.

I have selected for my first section, the country lying between Comstock's landing, Washington county, and Middle Granville, a distance of ten miles in an easterly direction. This section is important as it passes over in the first place the primary and lower Silurian rocks. It is instructive, because it exhibits the relations between the latter and the Taconic system, and it gives us a very clear succession of the upper rocks of the system. The sequence of the series is given in the annexed woodcut, No. 9.

A, gneiss, Comstock's landing; 1, potsdam sandstone with the overlying calciferous sandstone; 2, calciferous sandstone; 3, chazy limestone; 4, slates interlaminated with fine grits of the Taconic system; 5, overlaying mass of chazy limestone; 6, thin bedded sandstone embracing four or five thick beds of pallure; 7, uneven bedded slates or shales; 8, thin bedded sparry limestone; 9, bluish slaty grits; 10, calcareous coarse sandstone; 11, gray sandstone; 12, flags containing fucoids alternating with thin bedded slates; 13, beds of cherty sandstone; 14, blue slates; 15, thick bedded sparry lime; 16 and 17, roofing slates, containing a bed of sparry limestone forty inches thick. These slates are blue, purplish and red; 18, hard thick and thin bedded coarse grits; 19, slates with beds of grits; 20, red slate; 21, slates and coarse grits alternating; 22, sandstone passing into breccia and embracing thin bedded slates; A, dislocation Pond mountain, and 23, thick bedded sandstone, breccia interlaminated slates. These upper beds are found at Bird mountain, Grafton and Alps, Rensselaer county, N. Y.

The series just enumerated and briefly described, begins at a point near North Granville which is now uncovered by removal of the lower Silurian limestones. The latter extend eastward on the sectional line about three miles and a half from Comstock's landing though not continuously. The Taconic rocks are exposed in a gorge through which the Mettowee flows, and in which the calciferous is exposed in one place abutting against a ledge of hard Taconic shales. Farther east, perhaps a quarter of a mile, the chazy limestones containing Maclurea magna, may be observed resting upon the slates, both of these rocks, the calciferous and chazy limestone, extend beyond the potsdam sandstone.

The fourth rock in the ascending order consists of a series of black slates and fine grits. The dip is east, varying from east to east 10° south. Angle of dip from 30° to 57°. A part of the series which succeed the foregoing, and which extend to the thin bedded chazy limestone, consist of thin bedded sandstone alternating with green thin bedded slates, embracing a few thick bedded sandstones. I am unable to state their thickness accurately, but have estimated it at 1500 feet. The thin bedded blue limestone which is destitute of fossils, is only 12 feet thick. 10, The calcareous sandstone, this is separated from the limestone by about 100 feet of bluish slaty grits No. 9. The calcareous sandstone is a coarse grained rock containing from fifteen to thirty per cent of carbonate of lime, and six per cent of oxide of iron. The carbonate of lime is usually dissolved out of that part of the rock near the surface, and hence it becomes brown and porous and frequently a light spongy mass of a drab color, sometimes it is a coarse brown friable grit of slightly coherent grains of quartz.

The different beds of this rock traverse the whole county. Their thickness is 12, 15 and even 100 feet. They are situated near the beds of limestone, being separated by slate and slaty sandstone, but I have never observed that the calcareous sandstone ever passes into the sparry limestone. The rock which succeeds the calcareous sandstone is a gray or greenish gray sandstone. It is finer than the former and does not weather to a drab, or disintegrate so much. 12, Flags containing an abundance of fucoids. These masses are really thick bedded slates splitting into layers from one and a half to three inches thick These alternate with thin bedded slate. Above the latter there comes in a succession of cherty beds, vitrified masses, mostly thin bedded and of green or greenish color. The rock breaks with a conchoidal fracture, and much of it is a perfect hornstone, and is about 100 feet thick. 14, Blue slates which contain a bed of quartz 30 feet thick, above the quartz rock the slate becomes coarse and is really a gray or greenish gray sandstone. 15, Sparry limestone. 16 and 17, Roofing slates; the lower beds are uneven bedded, but pass into even bedded roofing slates which are divided by a singular bed of sparry limestone, forty inches thick. The slates are very firm and free from sulphuret of iron. They are blue, purple and red, and will receive a high polish.

In addition to the common material for roofing, these beds furnish fine even beds of flagging, two and two and a half inches thick, which appear perfectly solid, and in which it is impossible to discover the slaty cleavage which in these beds coincide with the planes of bedding.

These beds occupy, it will be perceived, a position considerably higher than the Hoosick roofing slate, and it will be seen also that their relations differ materially from them. They contain branching fucoids, but no graptolites have been observed among them. Over the slates I find a gray coarse grit, or rough sandstone somewhat similar in appearance to the calcareous sandstone or grit already described. The beds are thick and uneven, and do not readily split. Between these sandstones and the bright red slates, there intervenes a thick mass of slates containing harsh greenish grits. The red slate is the most remarkable rock of the series, being perfectly well defined and extending through the whole country; they cross the road at Granville corners and pass Middle Granville about a half a mile to the east. The beds of slate is 150 yards across, and have an angle of dip about 45°. They are titanium red, and stand the weather better than any variety of slate in market. Grits and slates into which beds of sandstone are introduced succeed the red slate, and as the coarseness increases, the sandstones become predominant, and finally, we find conglomerates and brecciated conglomerates. They are exceeding hard and tough, and are only slightly subject to disintegration. They are usually greenish and often look like porphyry. Chlorite forms a part of the paste in which the pebbles are inclosed. This series terminates with the brecciated conglomerates. This line of section extends twelve miles. The average dip for the whole distance is about 40°, and as the succession is not repeated, or if so it is not recognized, the thickness is not less than 25,000 feet.

In comparing the series with the Hudson river, we can not fail to observe many striking differences. The greatest thickness of the Hudson river slates and sandstone, in Albany county, is 700 feet, and although Prof. H. D. Rogers gives 6,000 feet as the maximum in Pennsylvania, still in Virginia it is not over 700 feet on the western slope of Walker's mountain. If we begin an examination at a high ridge, three-fourths of a mile southwest from North Granville, and then extend our course east to the Pond mountains, we keep in sight the several rocks of the section, or we need not lose sight of them. At the western base of the Pond mountain, four miles east of Middle Granville, there is probably a dislocation. What I mean to assert is, that the evidence renders it probable that the succession is without a dislocation, or repetition. We find continually new members of the series in the ascending order. If this is true, and even admitting faults and dislocations, the series forms a physical group unlike either the lower Taconic rocks, or the Hudson river. It would be a perfect geological anomaly if we succeeded in making out both divisions of the Taconic system equivalents of the Hudson river group. The upper and lower divisions, however, are both claimed, but the sections for their illustration show that neither can be regarded as lower Silurian; for neither one nor the other can be brought as physical groups into coordination. The assumption becomes ridiculous when it assumes that both, which are so unlike each other in their general and special characteristics, are metamorphic Hudson river slates and sandstones. As the difference existing between the upper and lower Taconic rocks has been attributed to a higher degree of metamorphism only, it is fitting that this view should be met with a few remarks in this place. Metamorphism occurring in the sedimentary rocks is usually produced by the presence of pyrocrystalline, or pyroplastic rocks intruded among them. But from North or Middle Granville to the highlands of the Hudson I know of no trap, porphyry or granite. There is therefore a cause wanting to produce the condition claimed; a condition which has really no existence* unless it is found in the marbles of Berkshire, Rutland, etc. It is scarcely necessary, however, to dwell upon this assumption; for even if the fact respecting metamorphism was true to the whole extent claimed, it could not become a material argument in proving the Taconic rocks to belong to the lower Silurian

NOTE.—On opening quarries for slate, flags, etc., it sometimes happens that very limited dislocations occur, involving a derangement of some eight or ten feet, but by dislocations and inversions such as involve the repetitions of an entire series of beds, many hundred or perhaps a thousand feet thick, I am confident do not occur upon any line section which I shall give.

* In the case of marble the assumption is uncalled for, inasmuch as the limestones which belong to the primary series are white and crystalline; the debris from a limestone in this condition, would, when consolidated again, be as white and crystalline as the parent rock.

period. Metamorphism only changes the physical condition of rocks, and the causes which are intimately connected with it, may so far change the conditions of masses locally, as to obscure their characteristics, but the succession remains essentially the same, and in this respect it is impossible that metamorphism could have been an agent in effecting the differences which exist.

§ 42. *Topography of the western part of the belt through which the section runs.*—Before I attempt to describe the parallel series south of Granville, it will be instructive to bring before the student certain facts respecting the topography and geological structure of the belt which skirts the valley of the Hudson. If we ascend the highest points of land in the western margin of this valley, we shall see northward a series of knobs of a moderate height rising along this margin as far as the eye can see, and if we go up the valley we shall pass these knobs, which we shall find occurring every two or three miles and which are separated from each other by oblique valleys, which connect the bottom of the Hudson valley with the table land immediately east. This range of knobs is an important landmark, as it lies along the great Hudson river fault, and indicates its eastern side. This line of fracture and dislocation runs N. 37° E. East of this range of isolated hills, which rarely exceed 500 feet in height, the country rises in ranges of hills and low mountains, which run parallel with the line of fault; and where the ridges approach the Green mountains we find that they, too, are situated upon lines of fractures parallel with the first.

But to return to the consideration of the first line of hills or knobs. I wish to state, in the first place, that they are usually capped with the lower Silurian rocks similar to that of Cantonment hill; thus Bald Mountain, Mount Tobey and Willard's mountain, with many others, are lower Silurian at their summits. Now, when we look beneath the lower Silurian beds we invariably find them reposing upon the Taconic system. It is true we are not always able to see the line of junction; but one observation which gives us the result I have stated is enough to settle the fact as it regards all of them. But it is true that in almost every instance the junction can be seen, or else the relations are so clearly indicated by phenomena, in each respective case, that we are scarcely left in doubt respecting the supposition I have just affirmed. I do not wish to follow up this point any farther at this time, and I have only to state that my lines of section are selected with reference to these knobs. The one already described and illustrated with a wood cut passes through a hill three-fourths of a mile south-west from North Granville across this line of fracture where the thin bedded blue limestone occurs. The Silurian system does not reach this point, but remains in the valley west, occupying here the same relation to the Taconic system that it does in the knobs I have spoken of.

The next sectional line I shall describe runs through the trilobite locality four or five miles north of Bald mountain. The slate in which I found the trilobites is in the road near the house of Mr. Reynolds. The rock is a dark green slate, the surfaces of which are glazed, or often appear as if they had been covered with a black varnish. When split through planes which are only imperfectly fissile, the fresh surfaces are ferruginous. It is here that the Eliptocephalus and Atops were found, both of which have proved to be not only new species, but to belong to new genera, unless indeed the first is a Paradoxides with which it has certain characters in common.

The slates dip east 10° or 15° south at a steep angle; westward the surface rises into a ridge, and the rock becomes more slaty and takes in calcareous beds. Upon the top of the ridge one-fourth of a mile west, the calciferous sandstone occupies the ridge, and at its western base are the slates conformable to the trilobite beds. Eastward from the trilobite beds, the same rock continues 100 or 150 feet, when it becomes a hard quartz rock, some ten or fifteen feet thick, which passes into a black shining slate, which in its turn changes eastward into coarse grits. A meadow some eighty rods wide intervenes between the road and a ridge, three-fourths of a mile east; when upon its western slope we found fine green slate cropping out at its base, which in ascending becomes coarse and ferruginous, and layers of a quartzose sandstone and thin bedded grits and slates. At the top again, or just over the eastern slope thin bedded quartz filled with particles of oxide of iron forms a mass twenty or twenty-five feet thick.

This locality with its grits, slates, quartz, &c., has been regarded as the equivalent also of the Hudson river group, the presence of trilobites is taken in proof of the assumption, both of which, however, have been shown to be new, and are not known to occur in beds with the other characteristic fossils of this group. Besides, between the trilobite bed, in the calcareous slates, which would be the equivalent of the Trenton limestone, fossils have not been found at all. So constant are Trenton fossils in Trenton slates and limestones, that there is no known exception in New York, Pennsylvania, Virginia and Tennessee, of their absence in the beds of this period. Besides, the beds above the trilobite beds, though there are very good exposures of the masses for half a mile, do not contain fossiliferous bands as in the true geological Hudson river group. It would be regarded as a very singular anomaly, if these rocks should turn out to be the Hudson river group and that all their fossils should disappear the moment they were raised to the surface on the east side of the Hudson valley, when at Snake mountain nearly opposite and a few miles only distant, the Hudson river group is finely developed and its members highly charged with fossils. Again, the group is physically different and its characteristics stand out strongly in contrast.

Dr. Fitch's Section through Washington county.—Dr. Fitch of Salem has published* a section through Bald mountain, in which we agree in the sequence of the rocks, excepting those at Bald mountain, which represents the limestones as dipping beneath the black slates, etc., instead of which, it is perfectly plain, that the limestones rest upon the slates. Beginning

* Transactions of the N. Y. Agricultural Society, page 820.

above the limestones, his section reads: 1, black slates with trilobites, answering to my section at Reynolds; 2, slates in the ascending order, argillaceous and silicious slates; 3, thin bedded limestone, equivalent to the first limestone in my section; 4, sandstones, answering to the first sandstones in my section; 5, silicious slate; 6, sandstone; 7, limestone; 8. green flinty slate; 9, slates with fucoids; 10, red slate; 11, sandstone, 100 feet thick, answering to my calcareous sandstone; 12, limestone; 13, slaty beds of sandstone, containing fucoids; 14, sandstones; 15, sandstones, these are the thick bedded sandstones of my section at Granville; 16, fucoids; 17, limestone; 18, chocolate colored slates; 19, glazed, and 20, black slates; 21, soft, green and variously colored crushed slates, which no doubt are the equivalents of the Columbia county roofing slates; 23, sparry limestones; 23, soft talcose chloritic slates The section terminates in the quartz rock dipping west, and conformably to the gneiss of the Green mountains, a representation, which if true, is certainly uncommon. Slate in the upper division, it will be seen, occupies more space than the shale or sandstones, and their condition is rarely changed sufficiently to obliterate the organisms if they were ever the receptacles of any. It is in slate that the many thin beds of limestone, calcareous sandstones, gray sandstones and brecciated conglomerates occur It is a system really protean from the numerous kinds of rocks which it contains. When the rocks are opened in quarries, we find them more protean than the unbroken surface indicates; thus in a slate quarry at Salem, four or five thin beds of limestone occur which were not seen before it was opened. The soil covers large areas and conceals much that would be important in assisting us to make out those details which are required for a full knowledge of its inorganic composition. Sections corresponding to those of Washington county might be described, also, in Rensselaer county. A brief notice of one passing from Bath to Alps, fifteen miles east, is all that I deem necessary to give at present. At and from Bath, three miles east, the rock is mostly concealed by Albany clay. A ridge of rock near Blomingdale crops out with a steep west dip and continues more than one-fourth of a mile eastward. These steep dipping rocks belong to the Hudson river group. Just east of Blooming Grove the Taconic slates crop out with a southeast dip, at an angle of about 35°. The slates contain a few hard silicious layers. The masses are so well exposed either in the road or adjacent fields that it is possible to obtain an unbroken succession of beds to East Sandlake, a distance of seven miles. The rocks are mainly slates, flags and thin bedded limestone without fossils. At Sandlake, the rock has become a thin bedded sandstone alternating with beds of greenish slates. These continue with a few variations to Alps, where we begin to obtain overlying conglomerates and breccias, more or less chloritic, which continue up the next rise of hill east from Alps. From these brecciated beds we pass to the lower Taconic series in Stephentown, consisting of talcose slates with limestones and marbles.

At West Sandlake there is a dislocation, but west from Blooming Grove to this place, a distance of four miles the sequence is unbroken. That a very minute examination might detect dislocations upon a small scale is highly probable. The average dip is 40°. We have therefore on this section the same facts which sustain the view already expressed, that this series is enormously thick. At one point on this section, there is a change of dip for thirty or forty feet, but the rocks resume their regular dip so speedily that it seems to be only a local variation which has no influence on general results.

A section in Prof. Mather's report of the geology of the first district of the New York survey and extending from Poughkeepsie east to Sharon, Conn., gives the same or nearly the same details. This section crosses the Taconic system, as we find in the series of rocks indicated upon the section, green, red and black slates, silicious slates, thin bedded limestones interlaminated with thin and chloritic slates, etc. The section is not designed to give a detailed illustration of the rocks over which it passes; but it contains enough to show that the protean group of slates, shales, sandstones and limestones, belong to the same series as those I have described in Washington and Rensselaer counties.

This series crosses the Hudson river between Poughkeepsie and New York and passes through Orange into New Jersey and onward to Pennsylvania and Virginia.

The next section which I shall describe, runs from Abingdon, Va., to Taylorsville in Tennessee. The rocks at Abingdon, Va., are limestones, alternating with beds of green, red and chocolate colored slates and gray and red sandstones. On the road leading to Taylorsville, the principal rocks are slates and limestones which are frequently exposed, but which generally are quite irregular in dip, being much bent or arched, so that frequent repetitions occur. I notice this route because I found a portion of the upper series much better exposed than in other sections, where the series are even much less disturbed.

At the ford on the middle fork of the Holstein, the limestone on the west side dips southeast with an angle of 80°. This is succeeded by heavy beds of green and black slates; but the beds are frequently concealed.

Thirteen miles from Abingdon, having passed over repeated repetitions of slate and slaty sandstone and limestone, there is a change in the rocks. The first intimation of a change is the occurrence of a low flat arch of reddish thick bedded sandstone alternating with slate; it overlies the slates and limestones which have been referred to. The sandstones are both reddish and gray, and continue exposed on the road, and constantly increasing in thickness for three or four miles, where the thick bedded sandstone is succeeded by conglomerates, breccia and interlaminated slates. The breccia is often feldspathic and resembles porphyry, but it is found to be on a strict examination a sediment, made up of or derived from a flesh colored granite. Both the sandstones, and brecciated conglomerates are chloritic, and hence this deep green trappean color. On comparing this formation with that of Grafton mountain, Rensselaer county, N. Y., I find there is a perfect similarity. It is impossible to distinguish specimens apart. On the Laurel a branch of the middle fork of the Holstein, 16 miles from Abingdon, this series attains probably its greatest thickness. Here the conglomerates and sandstone are at least 500 feet thick in a single cliff.

This section is important as it confirms the opinion already expressed relative to the succession of the rock of the upper division. Here the thick bedded sandstones and breccias are seen in position overlying beds of the thinner bedded slates and limestones.

In approaching the Iron mountain, as it is locally called, from the occurrence of brown hematite as in Berkshire, the thick bedded sandstones and conglomerates thin out, and we pass over a succession of blue and red slates with gray slaty limestone belonging to the lower division. These continue to Taylorsville. The lowest of the rocks of this division are the talcose slates and quartz, which are passed over on the route to Jeffersonville in Ash county, N. C. Stone mountain is an enormous development of these rocks and has already been referred to.

§ 43. *Great Limestone Valley of Virginia and Tennessee.*—The limestone valley of Virginia is celebrated the world over for its fertility and its wealth. The flowing outline of its hills, with their green slopes, forms a beautiful picture for the painter. It is no less attractive to the geologist, for here are some of the finest developments of the palæozoic formations which the country affords. The limestones belong in part to the lower Silurian and in part to the Taconic system. While the former maintain their usual developments, and resemble in almost all respects the same rocks in New York and Pennsylvania, the limestone belonging to the Taconic system seems to be much greater in extent and thickness than in the northern states. To illustrate in part this view I made a section in Wythe county, near the residence of Colonel Rapier, a gentleman well known in Virginia. The limestones and interlaminated slates and sandstones are so well exposed by the road and adjoining fields, that the true sequence is easily determined. Fig. 7 illustrates the secession or sequence of the rocks at this place. Their dip is

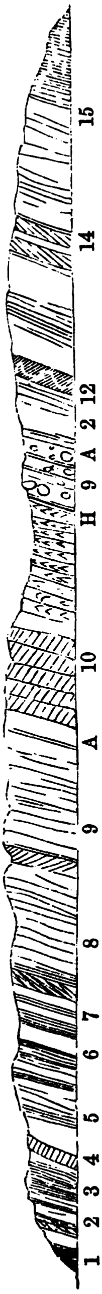


Fig. 10.

nearly southeast, and usually it amounts to 40°. The section extends one and a half miles, nearly at right angles to the dip. The enumeration is in the descending order:

1, hard sandstone thirteen feet; 2, fine grained sandstone sixty-five feet; 3, slates 300 feet containing beds of limestone six feet thick; 4, blue limestone thirty-six feet; 5, purple sandstone 464 feet, and containing purple slates twelve feet; 6, decomposing drab colored slate 250 feet; 8, cherty limestone; 9, green and drab colored slates; A A includes the blue limestone; 10, concretionary limestone associated with brown hematite; the thickness of these limestones is 1400 feet; 12, red and purple slates 200 feet; 13, red and green slate 400 feet, containing a few beds of limestone: 14, chocolate colored slates 600 feet, containing a few beds of slaty sandstone; 15, coarse slaty sandstone.

It will be observed that this mass of limestone is bounded on each side by beds of slate and sandstone, with but few beds of limestone. This section I believe corresponds, at least in part, to the upper Taconic rocks of Washington county, New York. If so, the limestones which are known in the slates at the north must have become much thicker in their extension south. I am, however, unable to account satisfactorily for the development of limestone in Virginia and Tennessee and throughout this great valley. A question will probably arise, whether these limestones may not belong to the Silurian period. On this question I remark, first, that as a group it is not Silurian; second, considered palæontologically, it is not Silurian, inasmuch as it is destitute of fossils. After devoting some time to a careful examination of the weathered surfaces of the limestone and also to fractured surfaces, I was unable to discover a trace of organization. In this examination, I believe every bed received attention. I inquired of stone masons and of those who were constructing roads, if they had seen a fossil of any kind in these limestones, and the answer was always in the negative; still, it seems probable that they will yet be found.

In respect to organisms, then, they stand out in strong contrast with the lower Silurian limestones of the neighborhood, for the moment these are examined fossils are found abundantly. The geologist may pass from the nonfossiliferous limestones and interlaminated slates in half a mile to the Trenton and Chazy limestones, and he will find there all the characteristic fossils which belong to them in the valley of the Mohawk. Again, it is not metamorphism, which renders the rock so perfectly barren of organized bodies, nor to the presence of chert or deleterious matter.

It seems, therefore, that the absence of fossils is significant of the period in which they were found, and this opinion should be received until it can be shown by the presence of characteristic organizations that they belong to the Silurian period.

I now propose to connect the last section with another (fig. 8), which includes the carboniferous and lower Silurian in the relation which they hold to each other, in the whole of the south-western part of Virginia.

1. Limestones of the Taconic system, which constitute a part of the series in fig. 7, and which are connected with slates, sandstones, &c. At this point they form the north-western part of a synclinal axis, which terminates against the carboniferous system, 2. On the west side of the fracture the systems are separated from each other only a few yards; 3, black calcareous slates of the Devonian period. The carboniferous and Devonian are represented by a series less than a thousand feet thick, and hence all the upper Silurian and most of the Devonian and carboniferous are absent; the Devonian is represented by a few beds only, which rest immediately upon the Niagara group, A. This is a cherty, concretionary and lumpy mass, a perfect confusion of beds. 4. Clinton group, with its beds of sandstone, slate and oolitic iron; 5. Medina sandstone; it always forms the crests of the mountain ranges of this region; 6. Lorraine shales, consisting also of green sandy marls,

even bedded, and weathering to a drab color; below them the black colored calcareous shales with chætetes, Leptæna sericea, alternata, &c.; 7, A mottled sandstone, terminating in beds of conglomerate, and which may be an equivalent of the Caradoc sandstone; 8, Trenton limestone, with Isotelus gigas, Ceraurus pleurexanthemus, &c.; 9, Birdseye and Chazy limestone, with Maclurea magna; 10, Calciferous sandstone; 11, Potsdam sandstone; F, fracture; 12, Carboniferous sandstones and shales. The distance between F F is about one mile. As members of the Silurian system, the series will require but few remarks at the present time, and in this place. They are brought in contrast with the Taconic series, and being rich in their characteristic fossils, it seems to me that this fact, taken in connection with the relations they exhibit to each other, places the independence of the Taconic system in a very strong light. It is plain enough that from 6 to 11, the series represent the lower Silurian most perfectly as it exists in New York, excepting the intercalated sandstone which contains fossiliferous bands, in which I found the Bellerophon bilobatus. As a physical group, the lower Silurian is in perfect accordance with New York rocks, and as an organic group it is very interesting to know that at a distance of one thousand miles from northern New York this series gives us such a perfect accordance also. The whole series from F to F does not exceed 4,000 feet in thickness, and that part of it included between 4 and 11 is quite as thick as in New York. A few miles eastward (about ten miles) the quartz rock, with its slate of the Taconic system, is thicker than the series included between 6 and 11. But I need not dwell on facts and arguments of this kind, especially when they may be regarded as inconclusive or not

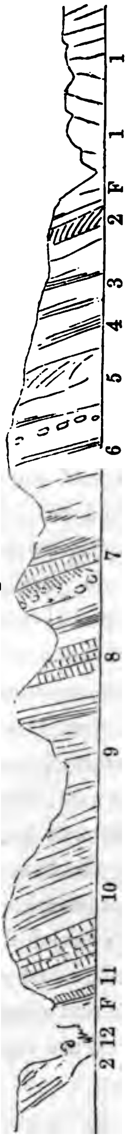


Fig. 11.

perfectly satisfying the evidence required. Still, I may add in this place to what I have already stated, that I believe that the Taconic series crops out from beneath the Potsdam sandstone at Shannon's on the north fork of the Holstein, sixteen miles from Wytheville; that the Taconic series plunges beneath the carboniferous at F, fig. 8, on the right, there is no doubt, and that it outflanks the lower Silurian is equally certain, inasmuch as it abuts against the saliferous and plaster series in Smith county. It, therefore, outflanks the Silurian or extends beyond it, at the western base of Walker's mountain.

There is probably no better section in Virginia than the one extending from Wytheville across the Iron, Little Brushy, Walker and Garden mountains, which furnishes that evidence in the form of contrast between the Silurian and Taconic system, which is very striking and conclusive. This section crosses the Alleghanies near the head waters of the Holstein, Clinch and one or two branches of New river. The easterly range of the Iron mountain is composed of quartz and the lower slates, from which we descend into the great lime stone valley of Virginia. Before reaching it we pass over many members of the upper division which crop out near its western base some two miles east of Wytheville. The latter place is upon the limestone commonly called the blue limestone, and which is finely exposed at numerous places in the valley. It evidently forms a synclinal axis, inasmuch as the rock east of Wytheville dips to the northwest, while near the base the dip of a similar series of beds is easterly at a steep angle. The dip, however, inclines towards the base of the Queen's knob, in the vicinity of which the most prominent rocks are carboniferous and lower Silurian, all of which dip southeasterly. The section, fig. 11, crosses the Little Brushy a little north of the Queen's knob. It passes only the first range. The ranges succeeding this as far west as Tazewell are repetition of the rocks of Little Brushy mountain.

THE FRENCH BROAD, HIWASSE AND OCOEE SECTIONS.

§ 44. The south furnishes many excellent sections of the upper Taconic rocks. The French Broad, after leaving the Warm springs in Buncombe county, cuts through a mountainous belt where the banks and cliffs upon the river show to good advantage the green, black and red slates; brown and gray sandstones interlaminated with slates and conglomerates. Beds of quartz nearly solid are not unfrequent, of which a remarkable one crosses the river about eight or ten miles west of the Warm springs; it is massive and thick bedded, and in consequence of its composition resists atmospheric agencies, and hence it stands out in bold relief on the mountain slopes. Hence it is a prominent cliff on both sides of the mountain which here encroaches upon the banks of the river. It may be traced up the sides or down one side of the mountain to the river's bank, forming a ridge where it crosses the road, and extending in an unbroken bed across it, it mounts up again on the other side to the top of the mountain to the height of 600 or 700 feet. The bed is fifteen feet thick, dips west or down the stream and makes with the horizon an angle of about 35°. The most remarkable fact is, that this massive quartz bed has been worn down so as to admit of the passage of the river. The part worn out is of the form of a horse shoe with the concavity directed up the stream. I had supposed that in almost all cases where rivers and streams flow through rocky gorges, that the rocks were first broken in the direction of the flowing stream but here there is no evidence of fracture. The river, it seems now, must have encountered this formidable barrier and have worn down the rock inch by inch, from 400 feet at least, down to its present bed.

The French Broad flows through a gorge for forty or fifty miles, or at least certain parts of its passage can be regarded in no other light than a gorge. The quartz rock which I have just described resembles a bed which crops out east of Lansingburgh, and which is known as the Diamond rock. Paint rock, six miles from the Warm springs, is a thin bedded gray sandstone, which resembles the rock between Blooming Grove and West Sandlake. Here thin bedded sandstone and shale pass into thick bedded ones with pebbly beds, succeeded by green and red slates and shales, in which there are beds of limestone. At Porrettsville, Tenn., black slates, and limestones alternating with them, are frequently repeated on the road to the Nolichucky, where the series seem to terminate in shales, shaly limestone, with intercalated silicious beds, similar to those in western Vermont. In the slates at Porrettsville, I found two or three species of graptolites. But I have been unsuccessful in finding organic bodies of any description in the rocks intervening between the Warm springs and Porrettsville. Black and green slates, sandstones and conglomerates and brecciated beds, roofing slates, etc., wall up both the Ocoee and Hiwassee, where they cut through the mountains between North Carolina and Tennessee. In all the southern exposures of the upper Taconic rocks, conglomerates are much more common than at the north. With this exceptian the strata are physically the same.

In Virginia the rail road from Waynesboro to within two miles of Staunton, passes over a similar series of rocks, in which we find a perfect representation in the sandstones, slates and slaty beds representing those of the Hiwassee, Ocoee and French Broad and the Laurel, as well as those of New York in all of the foregoing routes which I have cited, succeeding the lower Taconic rocks, and consisting of the same rocks with the same sequence, from Canada to Tennessee.

I have already stated that the Taconic system on the east side of the Blue ridge in North Carolina, Rhode Island and Maine, is represented only by the lower division. In North Carolina it spreads out widely, but is more restricted in Virginia, while in Rhode Island it is very limited, though distinctly developed. In Maine the upper division extends seaward to an unknown distance, being easily recognized at the Fox Islands, twelve miles from Camden.

My object in the foregoing pages has been to describe in the briefest manner the rocks and their order of sequence, which belong to the system under consideration. The plan of the work will not admit of further details, excepting when it is necessary to compare a member of it with one which it is supposed it represents in the Silurian period. The end I have had in view, has been to show that as a series of sediments the Taconic system is unlike the Silurian; or when we compare the two physical groups with the lower Silurian, we shall not fail to perceive they have only a few characters in common, and those have little importance; hence they can not be brought into correlation without doing violence to geological principles.

REVIEW OF THE OPINIONS WHICH HAVE BEEN EXPRESSED RELATIVE TO THE TACONIC SYSTEM.

§ 45. I have shown in the preceding pages that the Taconic system, considered as a physical group, can not be brought into correlation with any part of or with any group of the Silurian system; that no individual member of the former can be placed in coordination with an individual member of the latter; that the lower Taconic rocks, as a whole, differ from the lower Silurian as a whole, and that the quartz of the former is not the Potsdam sandstone, nor the slates the Utica slate, nor the limestone of that group the Trenton or blue limestones, as has been maintained by many geologists of this country. According to the views of several eminent geologists, the rocks of Saddle mountain, in Massachusetts, belong to the Hudson river group; the limestone below, in the position which I have given it, is the Trenton, and the quartz rocks the Potsdam sandstone. The whole group of the lower Silurian is developed in this mountain according to this view. If so, how does it happen that high up, towards Graylock, the summit, there are no fossiliferous bands. If these immense masses which are piled up 3600 feet are sediments, and of course this is admitted, how can it be explained on palæontological principles, that there are no organisms at all in the mass of the so called Hudson river group. It is said of course, that they are metamorphic. But then, what evidence have we that they are metamorphic; of course it will be maintained, indeed it is affirmed that they are destitute of fossils, because they are metamorphic, and they are metamorphic because destitute of fossils. For there is no trap, no porphyry and no granite in Saddle mountain. We must therefore assume that after thousands of feet of sediment had been deposited in the then existing seas, this portion of the earth's crust was again heated sufficiently to destroy all vestiges of organization which belonged to the upper part of the lower Silurian series. Which view is the most probable, that which proposes to refer this formation to a period prior to the creation of animals, or to a period which abounded in life, of which the vestiges were destroyed by heat and which was communicated through an immense thickness of rock? Heat communicated to the degree required should leave its mark, but we find nothing in the whole range of the Saddle mountain which looks like an igneous product or an igneous change. In all other cases where it is probable that fossils have been obliterated by heat, some monument of its agency remains to attest the fact, but in the case under consideration it is all assumption without facts or phenomena to favor it.

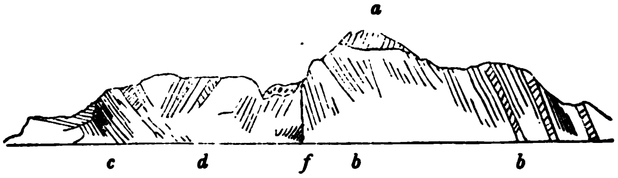
Now it is not necessary to tell American geologists, that the lower Silurian is eminently fossiliferous. Mr. Hall's work contains eighty-eight plates and 381 species. It is therefore quite strange that all vestiges of this large number should have been obliterated. But again, how does this doctrine of metamorphism stand by the side of certain alleged discoveries. For example, we are informed in the beginning of the first volume on Palæontology of New York, that fossils are found in the crystalline quartz rock of Adams, at the base of the Green mountains. It seems then, after all, that these eastern rocks are not so much altered, but that fossils are preserved at the very base of the system. Geologists should reconcile their discoveries with their assumptions.

But again, if Saddle mountain is lower Silurian, or Hudson river, how does it happen that as a physical group it is totally unlike the rocks of Granville, Salem, Pittstown and Greenbush, or the group which lies immediately on the slope of the valley of the Hudson and lake Champlain, both of which are also claimed as Hudson river. Where is the consistency in maintaining that both divisions belong to the Hudson river group, since they are unlike each other in matter and arrangement; and at the same time, that both are unlike the Hudson river group in all the essential characteristics, considered as physical groups. To say that there are slates, limestones and sandstones, is futile, for if the mere presence of the lithological masses makes identity, then they may as well be called the upper Silurian or Devonian as the lower Silurian. But similar arrangements or sequence taken in conjunction with lithological characters is what makes similarity in physical groups, and if there is not even a similar sequence then it is unsafe to assume, that two such dissimilar groups belong to the same period. It is only the strongest palæontological evidence, that such dissimilar groups can be ranked in the same period. But, I shall show that this kind of evidence is also against the assumption, so that viewed in the light of physical and palæontological evidence the assumptions respecting the Taconic system can have no support.

Again; it has been asserted by my friend Mr. Hall that the so called Taconic system is situated in the midst of Silurian rocks. The inference to be drawn from this assertion is, that the existence of the Taconic system under these circumstances is an incompatible association, which of itself overturns my position. But this association is the very fact which really establishes my doctrine, and puts the question forever at rest. I shall soon go on and show my mode of reasoning and my application of the foregoing assertion. It would be a waste of time for a geologist to set himself about proving that the Devonian rocks belong to a later period than the Silurian. And why? Because we know that the Devonian rests upon the Silurian, it is the sequence of one period to that of another. It is precisely this kind of evidence which the presence of the Silurian rocks in the midst of the Taconic rocks gives us, and if this kind of evidence had been represented fairly there probably would have been much less controversy upon the question.

The first illustration of the use to which I shall put the Silurian rocks will be seen in figure 12.

Fig. 12.



It is a section in a part of the Hudson river group, at Greenbush, passing through Cantonement hill. Just above the river but below the old red mill, the slates *c* are crushed, but it is evident they dip to the east. At the mill *d*, the blackish sandstones of the Hudson river dip also east; half a mile further, sandstone again crops out, dipping steeply to the west. Just beyond, the green Taconic slates dipping E. 10° S. support a heavy mass of calciferous sandstone *a*, and slaty Trenton limestone. Viewing the position of all the rocks, we find that there is an anticlinal axis running at the base of the ridge at *f*, supporting the limestone. This anticlinal is on the line of the great Hudson river fault. The limestone, which is the most important mass, rests unconformably upon the green Taconic slates *b b*. The beds dip in part west as represented in the cut at *a;* but they are not uniform in this respect. But this diversity in dip is proof that it is not interlaminated with green slates below. One of my friend's opinions which he at one time expressed, was, that the mass was thrust up through what he regarded as the Hudson river rocks. Since that opinion was expressed, he has constructed a section of the hill, and has represented this limestone as the Trenton, interlaminated with the Hudson river slates, as he calls those at *b b*.

Now some palæontologists are willing to admit, that a few fossils may go up from the Trenton into the Hudson river series, but I believe that this is the first time that a palæontologist is willing to transfer the whole of the Trenton limestone with all its contents into a higher group. But it unfortunately happens that the calciferous has to go with the Trenton in this case. That there is an error in Mr. Hall's view is evident from the exposure of the slate on the north and south sides of the hill, which proves that this bed of limestone is not an interlaminated mass in the so called Hudson river group. Both palæontological evidence, and that of superposition, forbid such an interpretation of the phenomena.

The true explanation is this, the limestone is an outlier of the Silurian system, deposited upon the slates which outcrop from beneath it. It was elevated subsequently, and undoubtedly was covered by the Hudson river rocks also, which have been carried away by diluvial currents leaving the present mass as it is now exposed. If this is the true explanation, and I see nothing to conflict with it, then as it regards these two systems the inference is too obvious to require to be stated.

It is worthy of notice, that this instance of superposition of the group of lower Silurian rocks, is upon the upper members of the Taconic system. It seems fitting in view of this fact, that I should now show that the rocks of the same period overlie and rest upon the lower division of this system.

I shall therefore select from the extreme eastern part of the county of Rensselaer an instance of an overlying mass of calciferous sandstone upon the Hoosick roofing slate. It has been very confidently set forth that the occurrence of Silurian rocks in this region proved the error of many of my views respecting the age of the rocks under consideration, while on my part I maintained that these rocks in consequence of the relation they sustain to the Taconic system, proved the soundness of my position. Before I refer to the figure which illustrates the true and real relations which subsist between the two systems, I shall give, in a few words, an explanation of the structure of the narrow belt of country of which Hoosick falls may be regarded as the centre. On the west, about three-fourths of a mile distant, there is a ridge some 400 or 500 feet high which stretches along the Hoosick river about four miles. The eastern face of this ridge is partly covered with a broken mass of calciferous sandstone, carrying as evidence of its age the Maclurea and several other fossils. It extends about four miles also, but its beds are broken and dip in a disorderly manner sometimes east, sometimes west, steeply sometimes, and only slightly in others. Its continuity is broken, yet it continues the distance I have stated. Its irregularity in dip and its fractured condition prove, that it rests on an uneven bottom, and that it has been unequally moved; and, furthermore, can not form a part of the Taconic rocks exposed below, upon the hills and in the valleys.

The limestone is discontinued before it reaches the river; on the east side of Hoosick falls is a ridge of about the same height running parallel with that on the west side. It is the ridge which furnishes the Hoosick roofing slates, quarries of which were opened forty years ago, and in which the graptolites occur. On the eastern slope of this ridge of roofing slate limestone occurs of the same period as that upon the west side. The limestone of this valley contains the fossils of the lower Silurian period, and hence we are not left in doubt respecting the most important palæontological facts. It remains now to determine how this well known limestone is situated; whether it does or does not form a part of the slaty group, or whether it is a part or parcel of it, in which case it would undoubtedly follow that the slates themselves are Silurian also, inasmuch as the limestone is Silurian, carrying the proof of its period in its fossils.

Now, it might well happen, that its true relations could not be determined by actual inspection; and in consequence of a nearly conformable dip with the slates, it might appear to form a part of the group with them. But at the outset, an honest and well meaning palæontologist might inquire what right has the calciferous sandstone to force itself into the company of the Hudson river rocks—what right has it to be interlaminated bodily between their beds? But leaving such impertinent questions to be answered by my friend the state palæontologist, who maintains that all these rocks, limestones and slates, are Hudson river rocks, we may proceed to determine the fact. It fortunately happens that this limestone lies upon the eastern face of the ridge upon which the state quarries are opened. Fig. 12 represents the situations of the limestone to the slate beneath.

Fig. 12.

a, limestone: *b*, slate.

This mass of limestone lies upon the east slope of a steep ridge, and the first impression which would be received by any geologist would be, that it belongs to the group of slates. The dip to the eye is so nearly conformable to the slate that it would probably be regarded as an interlaminated mass. When, however, its position is ascertained partly by a natural and partly by an artificial exposure, by the removal of earth to obtain the slate for a firestone, its superposition is proved beyond a doubt, and the idea of an interlaminated mass at once disposed of. The rock had been quarried for lime many years ago, and the excavation for slate led me to examine it in this place, when it was not only found to be above the slate, but reveals other important facts along the junction of the rocks. The slate, for example, shows that it had been tilted up before the limestone was deposited upon it. The out cropping edges still preserve the stair-like arrangement, which we often see in slate beds which are inclined at an angle of from 5–7°. It was upon this unequal step-like surface, that the slate was deposited, and the consequence is, that the bottom beds of limestone are roughly crushed and partly perhaps concretionary. The junction of the rocks is so well exposed from top to bottom, that only one opinion can be adopted respecting the position of the limestone, of which the annexed cut shows most perfectly the relation of the two rocks. Now, in the absence of direct proof to the contrary, this limestone would have continued to be cited as a part of the group of the graptolite slate, notwithstanding the calciferous has no right geologically to occupy a position, or position above the Utica slate, for all the ranges of limestone west of Hoosick falls, as well as west of this place, belong to the calciferous sandstone; and it is quite fortunate that these beds are fossiliferous, containing stems of Encrinites, a small Maclurea, in great abundance, one which is found also at Bald mountain.*

If the Hoosick and associated slates and shales and thin bedded sandstones were what my friend Mr. Hall and certain other geologists say they are, then, to be consistent geologists, they should not group together rocks belonging to distant periods. It is true the limestone is the base of the lower Silurian, and the Utica slate near the top, but so orderly have the lower rocks been laid down that no instance occurs in this country or Europe where the two extremes are placed in contact. In these statements I am contending for a principle, and not to sustain the Taconic system. I have stated that the position of the limestone is fortunate, inasmuch as we can begin at the base of the ridge near Hoosick falls, and trace the slate step by step to a quarry containing graptolites, and then from the quarry we may trace the slate to the place on the eastern slope of the ridge, where the calciferous limestone rests upon this slate. It follows, then, that the slate is not the slate of Baker's falls, or the Hudson river series, which contains such an abundance of Graptolithus pristis as Mr. Hall is inclined to assert; but I shall show in its proper place, that the graptolite of the Hoosick slates is not the Graptolithus pristis. The extreme looseness and carelessness in observation is shown by the affirmation that the Hoosick roofing slate rests on Trenton limestone.† In the first place, there is no Trenton limestone in the neighborhood for it to rest upon, and, in the second place, the beds of calciferous

* The fossil alluded to is the Maclurea sorditda of Hall's Palæontology, the *Straparollus sordidus*, of D'Orbiny. Mr. Wilder, of Hoosick falls, who has accumulated a large store of information in his favorite branches of science, geology and mineralogy, has large slabs of limestone covered with this fossil. He accompanied me to the locality, and I am permitted to say that his views correspond with my own.

† Palæontology of New York, vol. I, p. 267; idem, p. 268.

sandstone west of Hoosick falls, which must, if any, be the underlying beds, *actually rest upon this same group of slates* which compose the slate quarries. The presence of the Trenton limestone, however, would not change or alter the conclusion which I have stated.

But the occurrence of the limestone, geographically and geologically, is important, as showing how observers may err by mistaking one limestone for another. In this neighborhood the marbles of the lower Taconic rocks occur not in immediate proximity, but sufficiently near to lead to error in their determination. These marbles and limestones it has been shown belong to the group of slates in which they are found, and it would not be strange if a bed of calciferous limestone with its fossils was found superimposed upon a bed of marble—not more strange than that the lower Silurian is actually superimposed upon an overlying slate of the same group. Hence we see that the doctrine of metamorphism would aid materially in confirming an error, if the position of the lower Silurian limestone was not determinable by actual inspection. But having determined it not only for once, but also in many instances, and shown that the limestone rests upon the group unconformably and therefore can not be a member of it, we are authorized to carry our generalizations farther, and say, that in all cases the lower Silurian holds the same relation to the Taconic groups (even in Canada) which I have shown they hold at Greenbush and Hoosick. That there may be no obscurity in these relations left to be cleared up hereafter, I have prepared several other sections which show how geologists have been deceived in respect to the superposition of these outliers of the lower Silurian system.

The section to which I shall now direct the attention of the reader is that of the Mettowee river, at North Granville. I select this, because I perceive that Dr. Fitch* was led into an

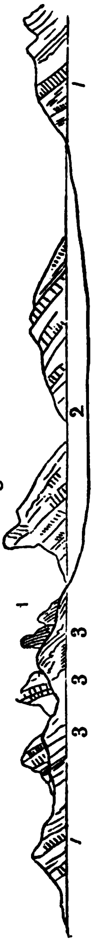
* Transactions of the New York State Agricultural Society, 1849, pp. 816, 907.

error respecting the true relations of the Chazy limestone, lying in a gorge of this river about one mile from the village of North Granville, and that I may not misrepresent Dr. Fitch's views, I shall first introduce his section, figure 13, with his explanation of the phenomena.

Fig. 13.

There is no disagreement between us respecting the name of the limestone represented in the cut. Dr. Fitch infers from the folded condition of the Chazy limestone that it has involved in it the slates which are in proximity, and hence, that all the cases of superposition I had relied upon, for proof that the Silurian belongs to a later period than the Taconic, was left unsupported. Now the fold in the limestone is correctly represented; there is a plication as the Doctor has shown. On the left, to use the Doctor's language, we have the black shale, or slate outcropping in the same situation, and in essentially the same manner that it does at Galesville. To this succeeds a thick molten mass of limestone, in which no distinct lamination can be traced. The synclinal, as the Doctor calls it, is finally reached, and the beds on the left side of the axis are less than half the thickness of those of the corresponding bed on the right side. The distance from the axis to the slate is forty feet; whilst to the right, thrice that thickness of the bed is passed over, without reaching the slate on the east, and the Doctor might have added more than ten times that thickness. The Doctor goes on to generalize, and remarks, that the Bald mountain range of hills is a fold, and not a fracture or uplift.

Fig. 14.



Without dwelling farther upon the illustration of Dr. Fitch, it appears from the fact exhibited on the south side of the stream, that the fold is confined to the Chazy limestone, and that it does not affect the underlying slates at all, and hence the fact of the plication of the limestone does not bear unfavorably upon the Taconic system, but as the phenomena really are, sustain the views I have adopted. To show how the limestone is placed with respect to the slates, I have introduced figure 14, which was constructed from the relations of the rocks as they are exposed on the south side of the stream, and a little below the great fold of Dr. Fitch's section. Thus 1, 1, Taconic slates; 2, Chazy limestone; the slate in this part of the section being concealed, but on the left three smaller folds of Chazy limestone are left standing obliquely upon their ends, and between which the slate is exposed. All of the standing parts of the folds, it is plain from inspection, may be removed from the slate, and besides the larger masses are seen also to rest upon them, though they incline downwards out of sight, but for forty or fifty feet it is evident the fold or plicated mass rests on the slate and can not form a part of the group to which the slates belong, but are simply crumpled up, or folded upon it. This view is sustained by the position of another insulated mass of Chazy limestone upon the hill north of this place,

Fig. 15.

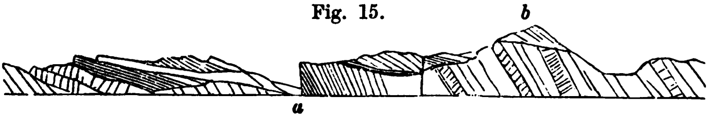


figure 15, *b*. My views are sustained also by other facts.

The rocks, on leaving Comstock's landing, fig. 15, are gneiss; 2, Potsdam; 3, calciferous sandstone; 4, Chazy limestone resting upon No. 3, but these rocks dip only at an angle of 5° until the Chazy, which extends east beyond the calciferous sandstone, dips so as to conform nearly with the Taconic rocks, on which it rests; the fold then only concerns the Chazy limestone, which is proof in itself that there is no general fold involving the plication of the slates, as has been maintained by distinguished geologists. Then again further down the stream, we find the calciferous sandstone abutting against the slates, figure 15, *a*, on a line of fracture; but this does not prove that the slates overlie the calciferous, for only a small part of the series of limestone appears at this place,* and besides, too, the highest member here, the Chazy limestone, *b*, is on the adjacent hill resting on the slates unconformably.

If for the sake of argument it should be admitted, or even it was proved, that the Chazy limestone is inclosed in a fold of the slates, which we know are beneath, what does it prove? Merely this, that it is an accidental occurrence, for the Chazy is only the subordinate part of the lower Silurian; it can not become, therefore, an associate of the slate group by itself. On the Mettowee it is separated from the calciferous by at least half a mile of outcrop of slates; and there is no calciferous below it at the fold. In conclusion, I say that the phenomena in the aggregate disprove the doctrine of such a plication as to affect the validity of my position respecting the Taconic system, and moreover the facts disclosed on the south side of the Mettowee prove that the folded Chazy limestone rests upon the edges of the slate, and therefore does not form a part of the

* This is an anticlinal perhaps which has passed into a fault; for on the one side is an older rock, Taconic, forced above a Silurian, the calciferous sandstone, the west side of the fracture being the most depressed, while on the east side the Taconic slates are the most elevated. We can not maintain consistently that the Taconic slates over-ride the calciferous; it would be physically impossible, seeing that the Chazy must at one time have been an overlying mass at this place.

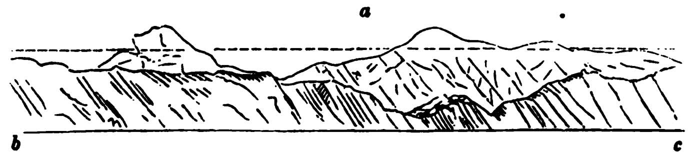
slate group, and is in no way connected with the slate except by its superposition.

§ 46. The gorge of the Mettowee discloses also the manner in which rocks thin out. We began this section with gneiss. The Potsdam sandstone is the next older rock. It appears that this rock speedily thins out, but whether it laps on to the Taconic system I am unable yet to prove, but the next oldest, the calciferous sandstone laps upon this system and extends east farther than the Potsdam sandstone. The Chazy limestone succeeds, and this extends still farther east than the calciferous and rests on the Taconic slates in its most eastward prolongation, where it dips almost as steeply as the inferior slates upon which it rests. But at the west, these rocks had a dip of only 5°. When, however, these rocks lie near the great north and south dislocation or fault their dips become steep.

§ 47. Before I proceed farther in answer to objections which have been made to the Taconic system, I propose to explain an obscurity which I have often met with, which, unless it is cleared up, is calculated to mislead or to raise doubts respecting the relations which really exist between the Silurian and Taconic systems.

At Highgate, in Vermont, the Missisquoi passes through a gorge just below the bridge. The Calciferous sandstone lines its banks on both sides, but some distance below, the junction of the calciferous sandstone is entirely concealed, even at rather low stages of water, and from the inequalities of the slate which jut up, it appears that the limestone might form a part of the group, by plunging down between the beds of slate. Thus in fig.

Fig. 17.

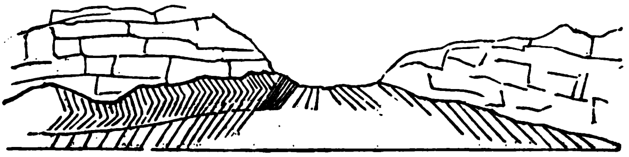


17 the dotted line represents the line of high water, where it would appear that the outcropping mass of calciferous sandstone, *a*, plunged between the beds of slate, *b*, *c*, which come up on the

right and left. On visiting this locality at a very low stage of water, I found that the calciferous rested in an irregular trough in the slate, and also upon its upturned edges. This fact explained all the obscurities which had formerly raised doubts in my mind respecting the relations of this rock to the slate; and, besides, the folia of slate are bent at the junction of the two rocks, fig. 18, which in this case I attribute to the force which has been communicated to the rocks, although it often occurs that folia of slate are puckered at the junction of a seam of calc spar with the slate. The phenomena at Highgate throw light on many other localities, where the lower Silurian rocks are in contact with the slates. Thus, one mile east of Troy, the junction of the calciferous resembles that at Highgate, but it is evident that the whole of the calciferous may be removed from the depressions, and from the unequal surfaces upon which it was deposited.

Another fact, however, at Highgate is worthy of attention, inasmuch as it proves the correctness of my view already expressed respecting the position of the calciferous sandstone. Thus, fig. 18, the spot selected for illustration is just below the

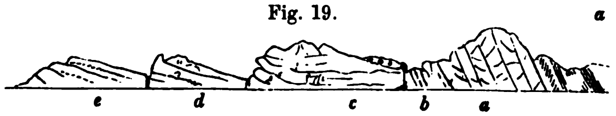
Fig. 18.



bridge. At very low water the slates appear in the bed of the river, and form an anticlinal at *a;* upon the upturned edges of this anticlinal the junction of the calciferous sandstone may be traced, with great distinctness, on both sides of it; on the right, the calciferous extends to and forms a mural cliff, on which a mill is erected. The possibility of the calciferous forming a part of the slate group is set at rest by this exposure.

I am now prepared to show how another error may be comitted respecting the period to which a limestone belongs; an or which I suppose has been already committed by several geologists. At Orwell, Vt., see fig. 19, the calciferous sandstone, *c*,

Fig. 19.



occupies the plain upon which the village is built. Eastward a few rods, a limestone, *a*, crops out in proximity with the former, but how many yards apart they may be I can not now state.

With only a superficial examination, they would be regarded as one rock, belonging to the same period. On a careful examination, however, it is clear that the eastern mass rests on a greenish slate, and by going east a short distance the evidence is plain enough that a slate, *e*, also overlies it, so that it is inclosed between beds of slate, and in this respect it is similar to the limestone which lies in the tunnel of the Western rail road near the state line, and which belongs to the slate group, as is clearly proved by observation. Having determined that the eastern limestone at Orwell lies between beds of slate, our convictions it seems should be, that it is not lower Silurian, nor Trenton, nor either of the masses into which the lower Silurian limestones have been divided. But what is the limestone on which the village is built? To determine this question, I traced it northward, keeping it in view for a few miles, and then turned directly west towards the lake. On passing over two or three rocky terraces composed of this rock, I came directly upon the Potsdam sandstone which cropped out from beneath this silicious limestone, and over which I had passed, and which I had traced from Orwell. The result of this examination proved that the rock at Orwell, which seemed almost to join on to the sparry limestone between the slates, is the calciferous sandstone. The two limestones therefore might be confounded, but without the aid of a fossil, the geological formation to which the calciferous sandstone belongs, is proved by simply determining its relations, and at the same time it is also proved that another limestone of a different period cropped out very near it, and might have been confounded with it. It proves, too, the fallacy of the doctrine, that the lower Taconic rocks, or the lower limestones, are but altered Silurian; we have two limestones of different ages together—one rests on the Potsdam sandstone, and is of the Silurian age, the other on slate, and belongs to the Taconic system. The theory of plications and folds it will be seen, will not explain the phenomena or the facts. It is not even a plausible hypothesis, when offered in explanation of the phenomena I have related. I have been unable yet to detect fossils in the sparry limestone of Orwell, but its condition is as favorable for their existence as in the calciferous sandstone. This locality proving the existence of a limestone which can not be placed in coordination with any of the limestones of the lower Silurian, throws the burden of proving the period to which it belongs on other shoulders, provided it does not belong to the Taconic system.

The sparry limestone at Orwell, when its relations are investigated, shows that what my friend Prof. Rogers claims as having proved is not yet established, viz: that the limestones of Berkshire are only the altered blue limestones of the lower Silurian, for this exhibits the same relations as the Berkshire limestones; and I go farther and remark, that the section of rocks from Orwell to the lake exhibit a series of dislocations and faults only; and though my section was not designed for this purpose, yet it shows the relations of the rocks as they succeed each other, beginning at Orwell and going west to the lake, in which distance there are no less than four dislocations; and the order of arrangement, beginning with the limestones is such, that we pass, by successive steps, from the oldest to the newest, terminating with those on the lake, the Utica slate and Trenton limestone, which we reach by a series of descending steps, though, geologically, we are ascending. Thus, figure 19, *a*, sparry limestone; *b*, *b*, slates; *c*, calciferous sandstone; *d*, Potsdam sandstone; *e*, Utica slate and Trenton limestone.

Bald mountain and the neighboring hills and ridges in Washington county, N. Y., furnish also many important facts bearing directly upon the relations the Taconic system sustains to the lower Silurian. This mountain is capped with the lower Silu-

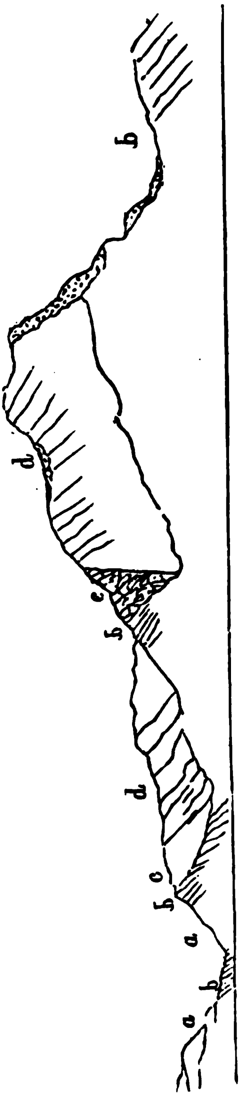


Fig. 20.

rian rocks; their position and situation are exhibited in figure 20; *c*, *d*, calciferous sandstone; the mass, *c*, is a compact black limestone, and appears unlike and distinct from the rock. Silicious and black masses perfectly well defined occur frequently in this neighborhood in the calciferous sandstone, but they are varieties of that rock notwithstanding their color. The Taconic slate crops out from beneath the calciferous at *b*, *b*, on the west or left hand side is slate rock; *b* appears on the east or right with a steep dip; at *c*, *c*, on the left, are fractures. The dark colored limestone, *c*, has been quarried for more than forty years, and the front has been worked back thirty or forty feet, down to the slate, *b*. The question to be solved at this place is, whether the slate, *b*, on the left, is the Utica slate, or any other slate of the Silurian system; there is no difference of opinion respecting the mass, *c*, *d*, all agree that it is the calciferous sandstone. If the slate, *b*, is Silurian, it follows that at this place there is a plication, and the slate is folded under the limestone. The fact which militates against this view is, that on the south side, and at a point nearly under *d*, near the summit, an excavation was made in search of coal; the shaft was begun in a lateral shelf of the limestone, near the base of the mountain. This shaft was carried through the limestone into the slate, *b*, beneath it. Now, this fact taken in connection with another, viz: that the limestone does not penetrate the slate on its southern flank any where between *b*, *b*, on the right, proves incontestibly that the limestone merely caps the hill. If it was a part of the slate group, we should find it in the direction of strike in the slate.

Again, if a plication exists and the slate, *b*, is the Utica slate, then there are facts brought together which involve a physical impossibility, inasmuch as the limestone upon the slate should in that case be the Trenton limestone, which always underlies the Utica slate; the calciferous sandstone could not, therefore, in the case of an inversion be brought into immediate contact as it is with the slate, but it should be the Trenton limestone. The fossils of the rock resting on the slate, however, are those of the calciferous sandstone, viz: the Maclurea sordida, Hall's Palæontology, pl. 3, fig. 21. They occur upon the thin bedded limestone towards the top of the hill, as well as in the more compact beds just above the slate. If, on the contrary, there is no inversion and the phenomena do not indicate it, then here is a slate which is not Silurian; it crops out from beneath rocks which are known in this country as the lowest beds of the lower Silurian and besides may be traced beneath the mountain and beyond it eastward, forming a part and parcel of the series, *b*, cropping out in the figure on the right.

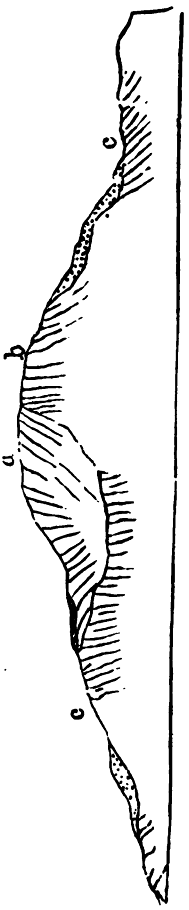


Fig. 21.

Now, all the knobs resemble each in this neighborhood in being capped in this way. Mount Tobey, fig. 21, not far distant, is an example of the same as figure 20, being capped with sandstone. The lower part of the limestone dips at an angle of about 10° to the east; on the contrary, on the top, at *a*, it dips steeply to the west. The slate beneath may be traced around the mountain, without exhibiting the limestone upon its beds. It is, therefore, a mass resting on the top of the mountain unconformably to *c*, *c*, the slate on both sides of the mountain. The slate at *b* dips steeply east. The dips, were there no other facts, decide the question of superposition.

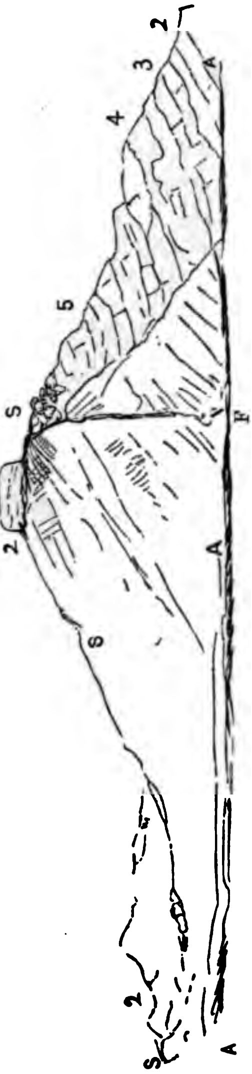


Fig. 22.

It has been stated in Silliman's Journal,* that Dr. Fitch found the Trinucleus concentricus in this region, adducing it in proof that the rocks belong to the Silurian system. This statement will not probably deceive any one. The fact, however, is important, as by it we prove the greater antiquity of the Taconic rocks than the rocks in which it was found.

§ 48. *On the structure of Snake mountain and the evidence its structure furnishes in support of the Taconic system.*—This little mountain in Addison county, Vt., is seven miles east of Lake Champlain. The rocks between the lake and base of the mountain are lower Silurian. The Trenton limestone with slaty beds lie upon the western flank of the mountain, fig. 22.

In the ascending order, 2, 3, 4 and 5, the rocks are calciferous sandstone, Chazy and Trenton limestones. And that I might exhibit the relations of the calciferous sandstone, 2, at the top of the mountain, it is made across its northwest angle, where in a few hundred yards we pass over to the slate S, S, which crops out both on the west and north sides beneath No. 2, and on the north side extends from the top to the bottom of the mountain. The Silurian rocks 2, 3, 4, 5, rest against the

*Silliman's Journal, vol. xix, for May, 1855, p. 434.

mountain. At S and F there is a fracture and dislocation which may be traced in the direction of the mountain axis, four or five miles. The dip of the Silurian rocks is from ten to fifteen degrees; of the Taconic slates, S, S, twenty-five to thirty degrees. At the northeast base of the mountain, perhaps three-fourths of a mile from its summit, the slates crop out again below 2, on the left, beneath the calciferous sandstone.

The summit of the mountain is calciferous sandstone and is exposed in a perpendicular mural precipice for four or five miles. The debris and fallen masses from this bold front generally conceals the underlying slate, but it crops out beneath it at one or two places, while on the north side, 2, S, the whole slope is exposed and consists of one mass of slate from the calciferous sandstone to the bottom of the mountain.

The calciferous sandstone in this region is often red or chocolate color, especially the inferior part of it. The gray variety at Burlington graduates into the red, and the Potsdam which is used as a flagging stone, at Burlington and other places, is usually brown or chocolate colored also. But the blue and gray with a sparkling lustre are found in the masses composing the mural wall at Snake mountain. The junction between the Taconic slate and Trenton limestone and its upper slates, or the Chazy limestone on the west flank of the mountain, has not been observed.

The foregoing statement respecting the relative position of the rocks of this mountain seems to be all that is required to establish the inference I have drawn from them. I need not dwell on the error which has been committed by regarding the chocolate colored rock the Medina sandstone, or attempt to show that the plication theory will not adjust the rocks so as to make the black and greenish slates, S, the Utica slate or Hudson river group. It is one of simple dislocation, where the older rock on the east side is elevated vertically higher and above a newer series on the west. The rocks, in this case, are not engulphed upon the west side; all the phenomena seem to prove that the whole mass composing the mountain was raised vertically, but the east side was separated from the west by fracture, and elevated above it. The series between the mountain and the lake occupy a much lower position than those upon the flank of the mountain, proving that the latter have been broken from the former and elevated above them. We find in Snake mountain a fact of common occurrence, a fracture at the base of the ridge or mountain, and another running through it. Bald mountain, which has been described, is another instance of this kind. In fine, with respect to Snake mountain, the position of the mass 2, on the top of the mountain, and which covers the eastern slope, proves that it is an overlying mass and an inspection of the junction of the inferior beds which often jut over and beyond the slate immediately below, proves that it was deposited upon the slate, and as the two are unconformable both in the amount of dip and direction it is also evident, that they do not belong to one group or series. At this place the former is the base of the Silurian system. It is very silicious generally, and might be called a sandstone, yet it is rather a mass intermediate between the calciferous sandstone and the Potsdam sandstone, It is the same rock as that at Burlington, and at Sharp Shins, two miles northwest of Burlington, where the same black slate crops out as at Snake mountain. Those who wish to satisfy themselves of difference between the Hudson river group and the slate beneath the calciferous of this mountain, should explore the north end of it, where they will find a mass of slate from top to bottom laid bare by a small stream which takes its origin immediately beneath the jutting calciferous sandstone, and which by this little stream has been undermined for centuries, and from which huge blocks have been, and are still broken and carried down the mountain's side, and are found distributed far and wide upon its northern and western sides. This slate is uncovered in a continuous mass between 700 or 800 feet thick. I was unsuccessful in a search of a few hours for fossils, and yet it is similar to other exposures where I have found graptolites.

§ 49. *Position of the calciferous sandstone at Hoosick and elsewhere compared with Prof. Sedgwick's ideal sections of the Skiddaw Forest, and the calcareous hills of Westmoreland.**— The sections of the older slates, which have been given by Prof. Sedgwick, of the Cambrian rocks, contain important facts which have a bearing upon the question respecting the existence of a sedimentary series or system below the Silurian. The section through the Skiddaw forest is in point as it enables me to contrast it with sections through the strata belonging to the Taconic system. For example, the relations of the Coniston limestone, 4 *a*, and the calcareous flagstones, 4 *b*, to lower Silurian of this country. It appears to have been determined as long ago as 1847–8, that the Coniston limestone, which is a part of the series in the section of the Skiddaw forest, contains lower Silurian fossils, but still lower a vast series of slates marked No. 3 in the section are found to be fossiliferous, and Prof. Sedgwick regards these lower series of slates (Skiddaw slates) in England, as the oldest fossil group of the British isles. This group, however, is conformable to the Coniston limestone which contains lower Silurian fossils. It is the position of the Coniston limestone compared with the position of the calciferous sandstone to which I wish to direct the attention of the reader; the former is a part of a physical group conformable with the lowest fossiliferous beds; while the latter is not a part of the group of slates, etc., of the series at all, being neither in coordination with a member or conformable to any part of the Taconic system But as American geologists have watched the discussions going on in England respecting the claims of the Cambrian system, and as all the representations of its strata carry the idea of conformability, not only among themselves but also with the Silurian system and as Silurian fossils characterize these lower beds, the opinion has gained ground that the Cambrian is only a modified condition of the lower Silurian, and hence the same view has also been taken respecting the Taconic system. The representations which

* Proceedings of the Geological Society, vol. iv., p. 216.

have been made have conveyed precisely the Cambrian type. Whereas the facts proving the relative age of the Taconic system contain another order of proof entirely. The Silurian limestones in the Taconic districts do not form, as I have shown, a subordinate part of the Taconic series, but they are always overlying unconformable strata, as represented in all my sections, the most instructive of which is the Hoosick section, fig. 11. It is in consequence of that misrepresentation of facts which has prevented the adoption of the Taconic system here and abroad.

Before I close my remarks on the objections which have been brought forward in opposition to my former views of the Taconic system, I feel bound to notice those which have been urged by Prof. Rodgers on several occasions when the question came up for discussion in the meetings of the American Association.

I have anticipated in the main Prof. Rodger's objections. But by stating the points at issue in a formal manner, I shall be able to clear up the objections to his and my own satisfaction. The principal fact is admitted, viz: that there are rocks cropping out from beneath the lower members of the Silurian system. If these rocks which crop out from beneath the Silurian beds, are not in their original relation or position, then the question of age is debatable. If these inferior rocks are in their original relation and position, then it follows that in this country there are fossiliferous rocks older than the Silurian system, for it is settled beyond a doubt that the Potsdam sandstone is the base of the system in this country. Prof. Rodgers maintains that the inferior slates, those at Bald mountain and upon that range, those at Snake mountain and at Burlington, Vt., Greenbush, Troy,* and many other places, are not in their

* I should state that Prof. Rodgers, in his remarks, has never given localities upon which he has based his opinions. He has referred to Snake mountain, but it was in terms which satisfied me that he had seen but a small part of the series, and hence was unprepared to express an opinion.

original position It is sufficient to say that at all the places I have named, this slate crops out from beneath rocks of the lower Silurian age. This is admitted by all geologists.

Now the explanation which Prof. Rodgers gives is this, viz: that wherever these relations exist which I have stated, they are due to an inversion of the lower Silurian rocks; and the superior masses are folded beneath the older; and as the strata are plicated in mass, and as the Hudson river group succeeds the limestones, the former consisting of black slates and sandstones in the plication, the latter are folded beneath the former; and hence this black slate which I have had occasion to speak of, is no more than the Utica slate, or a slate near its horizon.

Of this opinion, I do not propose to express doubts as to its being theoretically possible, neither to deny that it may exist as a fact. But I do say that from Georgia to Maine, there are no plications which create the least intricacy. I speak of phenomena and the interpretations which they themselves suggest, as rational interpretations which we should put upon them.

We have only to examine the localities in detail where the supposed plications exist, to be satisfied that the plication or fold has not reached the slate, and if the slate beneath has suffered a movement, it has extended its influence to the mass as an overlying one, prior to that movement; it has crumpled up the limestone between two ridges, as at the Mettowee, where the fold is still visible in the limestone, but not in the slate, or it is not such a fold as to place one rock beneath the other.

The objection to Prof. Rodgers' explanation must be considered also in a mechanical light, and attended with effects powerful in proportion to the masses displaced and laid in an inverted position. I maintain that the fitting mechanical effects of an inversion should be among the most prominent phenomena; whereas none exist. In the next place, admitting an inversion of all the Silurian rocks in a fold, so as to place the slates at the bottom, then upon the slate in the ascending order, we shall find the Trenton limestone, the next the birdseye and Black river, and lastly the calciferous and Potsdam sandstone, if the latter is present. We shall look then, if the theory is true, for the Trenton limestone, as the rock which rests immediately upon the slate; but what do we invariably find? It is calciferous sandstone, there is no exception, or Potsdam sandstone when it is present. This fact can not be reconciled with the theory of an inversion, inasmuch as it is a physical impossibility to arrange the rocks in the order we find them. Admitting again the theory of plication, I say it can not deceive us, or lead us into error. The theory supposes a succession of close plications or folds. In this case, every alternation in the fold corrects the error of the inversion. If the true order is determined, then, the series is a check upon its own errors. Besides, on the southeastern slope, before the inversion takes place, if there is one, the rocks must occur in their true order of superposition, and by the exposures on these slopes will prove a check upon their inverted position on the northwestern side. In proof that plications can not involve us in the error which has been supposed, and mislead as to order of superposition, I have found the Taconic slates on both sides of a ridge, and the lower Silurian, confined to the crest of the ridge, showing that the mass of the ridge is slate, with only a crest or capping of lower Silurian, which it seems to me proves there never was a fold or inversion, but a simple dislocation.

Facts are always useful aids when debating important questions. In the midst of the most disturbed districts of Virginia, at the head waters of the Clinch and Holstein, the lower Silurian never furnishes an instance of an inversion or plication by which the Lorraine sandstones and shales, &c., are folded beneath the Potsdam sandstone or calciferous sandstone. See fig. 8, where their order is represented. The insuperable difficulties, then, which attend this theory require its dismissal; besides the slate beneath the calciferous can not be regarded as the Utica slate, or any of the beds next above it, in the Silurian series. If it is carefully examined across the line of strike or dip, we find it in conformity with beds whose fossils are unknown in the Silurian system.

A theory which may be true in the abstract, and perhaps may be sustained by facts disclosed at certain localities, still when it fails to explain the phenomena at other places and is even entirely at variance with the principal facts, should be abandoned Its conditions require that the rocks when plicated should lie in a certain order, they must lie in a certain relation which the theory supposes, but it is almost needless to say, that the order in which they actually lie upon the lines of fault in Vermont, New York and Virginia, is entirely at variance with the position the theory requires. Indeed, when the theory is applied to the rocks under consideration, as explanatory of their present position it involves a physical impossibility.

SUMMARY OF PROOF CONTAINED IN THE FOREGOING REVIEW OF OPINIONS.

§ 50. 1 The proofs are found in the constant relation which the lower Silurian rocks hold to both divisions of the Taconic system, the relations being those of an older and newer system, inasmuch as the evidence of superposition in consequence of succession is an incontrovertible fact.

2. It has been shown that where the Silurian rocks were folded or plicated, the fold itself did not extend to the slate upon which the Silurian rocks repose. The fold is confined to the overlying and unconformable rock, so that in the cases of plication the evidence of different periods to which the rocks belong is strengthened.

3. Again, I have proved that when a member of the lower Silurian seems to occupy a conformable position to the slate beneath, and hence might belong to it as a member of a group, yet it is still proved that the mass is really unconformable and rests on an inclined surface of the slate, as at Hoosick falls.

4. It has also been proved that troughs in which a member of the lower Silurian group was deposited may deceive by conveying the impression that the included limestone belonged to slate as a member of the group, as at Highgate, Vt.

5. I have also made it evident beyond a doubt that the fact of the existence of Silurian rocks in the midst of the Taconic system furnish by their presence and their relations, the highest possible evidence of the existence of the Taconic system.

6. The strength of the evidence is increased (if possible) when it is considered, that these masses of Silurian rocks though really isolated. overlie both divisions of the Taconic system, that they are found at the western and eastern borders of the system and always occupy a position superior to and unconformable with the Taconic rocks upon which they rest. These overlying outliers dip in all directions, sometimes west and sometimes east and northwest, etc., according to local circumstances; another proof of the general unconformability with the system.

7. I have shown that the theory of plications has certain physical impossibilities to perform when it is attempted to apply it to any part of the Taconic system where the overlying rocks are of the lower Silurian epoch; the order in which the plicated mass must lie, being totally different from that which exists along the lines of fracture as at Bald and Snake mountain, etc.

THE TACONIC SYSTEM CONSIDERED AS THE REPOSITORY OF THE METALS AND AS A PERIÔD OF ERUPTION.

§51. It is a rare combination or phenomena which circumscribes an epoch of geological events so clearly and so closely that it can be referred to a subordinate part of a given period.

Indeed most of the references to periods are rather approximations than determinations, and probably the references which I may make of the epochs of veins and eruptive rocks in the Taconic system may partake more of the former than the latter. Still, when all the facts are brought together and weighed, I am disposed to regard the veins and eruptive masses which traverse this series of rocks as really belonging in part to the

Taconic period. This result which I have stated is rather confirmed by the fact that the presence of eruptive rocks is confined to the earliest part of the succeeding period, and hence it may appear that the eruptive period to which the veins and dykes of greenstone and porphyry belong may be referred with greater exactitude to both periods, the first part of the Taconic and the first part also of the Silurian period.

§ 52. *Veins which may be regarded as belonging to the Taconic period.*—The lower slate rocks of the Taconic system are remarkable in some parts of the country for the frequent occurrence of veins of milky quartz. In New England and New York they are white opaque masses traversing the rocks with very little regularity. They usually appear to thin out rapidly, running out from a large mass in thin strings, and to terminate very soon in the neighboring rock. Besides, they not only end speedily in a lateral direction as I have stated, but appear also to thin out beneath and to terminate in thin strings. So constant are these veins or irregular masses, that the talcose slates may be said to be characterized by them.

The minerals which are associated with this kind of quartz, are chlorite, sulphuret of iron in crystals, carbonate of iron and stains of manganese. They can not be regarded as metalliferous, notwithstanding we frequently find in them a few of the metallic combinations. But veins possessing the character of true veins also belong to the talcose and chloritic slates, which is their veinstone also, and I am unable to perceive that the quartz in its mineralogical characters differs from that already referred to. The veins, however, of the latter extend laterally and in depth to an indeterminable distance; and when they divide into strings, the fact may be regarded as an exception to the general law or rule which they obey.

The latter are metalliferous; and to this class we may refer both the auriferous and cupriferous veins of Virginia, North Carolina and Georgia. The rock in which the gold occurs in the southern states is regarded by many as the primary talcose slate, which is associated with hornblende, gneiss and mica slate. In North Carolina and Virginia these auriferous rocks are associated with breccia and conglomerates, and such are their relations that it can be no longer doubted that the formation of the auriferous veins comes within the epoch of the oldest sediments of the Taconic system; for although the porphyries and metallic copper veins occur in the lower Silurian, still auriferous veins appear to belong to a much earlier period. But again it is true, that many of the auriferous and cupriferous veins occur in the talcose and hornblende rocks of the Blue ridge, still as the veins run in a direction parallel with those of the Taconic system, they should therefore be regarded of the same age or epoch, and the auriferous veins of Somerset, Vt., should also be referred to the Taconic period.

Native copper occurs rather sparingly in certain porphyroid rocks in Chatham county and may be also cotemporaneous with the auriferous quartz vein.

§ 53. In addition to the foregoing metalliferous veins of this epoch, it seems to be established that it is also the period to which the veins of magnetic and specular iron belongs. In North Carolina both species of ore are found in veins traversing the slates which are associated or connected with beds of conglomerates as in Chatham county, four miles northwest of the gulf. Magnetic iron also occurs in Randolph county, N. C., in the same kind of rock as in Chatham.

In the first part of this work I have shown that the epoch of the production of veins of specular iron belonged in part to the lower Silurian period, inasmuch as the Potsdam sandstone is disturbed where the beds crop out. In northern New York, however, serpentine is the accompanying eruptive rock. The period to which a portion of the trap and porphyry belongs in North Carolina, is equally well determined as that respecting the auriferous quartz veins.

In this state, for example, there is probably one of the most singular belts of trap in this country. It traverses Guilford county, and the western part of Alamance, and pursues a northeasterly and southwesterly course across the state. This belt consists of numerous veins of trap, granite, quartz and feldspar which cross each other in various directions, and in their frequent crossings they form so complete a net work that the rocks traversed can scarcely be distinguished. That this singular net work of eruptive rocks, should be referred to an epoch as late as the Taconic period, is evident from the fact that it penetrates these rocks along its western border in Alamance, Guilford and Davidson counties, and it occupies in this system a belt of it, six miles wide, at least, and extends also into the adjacent primary district, so that these veins occupy a space between the two systems. But it may be questioned perhaps, whether these eruptive rocks may not belong to the Triassic period, or to one near the close of the palæozoic period. When we compare this net work or mass of dykes and veins with the trap of the last part of the palæozoic period, or a period extending from the last part of this period to the Triassic, we can not fail to discover a remarkable difference in the material composing them. In the latter the traps are not accompanied with veins of quartz, granite and feldspar; at least, I have not observed them. In the kind of matter and in the circumstances, there seem to be those differences which indicate that the two periods of eruption are distinct; and hence I am induced to regard the net work of eruptive rocks which occupy a belt between the Taconic system and the pyrocrystalline rocks as belonging to the Taconic period. We know that it comes within the period of sediments. But there are no positive data to fix it with certainty.

THE TACONIC PERIOD ONE OF ANIMAL AND VEGETABLE LIFE.

§ 54. This system is not less thoroughly peculiar in its organisms, than in its physical characteristics. It is true that the number of its fossils is small when compared with the Silurian period; but as far as they go they stamp upon it a distinctiveness which is as marked as that of the Silurian and carboniferous. But this is not all: we have a right to consider the absence of certain

Silurian fossils, a fact which looks favorably towards the view I have attempted to sustain. I admit that even the Silurian system is not equally rich in fossils in all its groups. In some instances their absence is accounted for on principles upon which all geologists are agreed, and which are considered as good and sufficient reasons for their absence. There are instances, too, of their absence, for which we can not assign a satisfactory reason. As a general rule, however, the fossiliferous bands occupy nearly the same horizons, and they are so rarely absent that the palæontologist always expects to find them. It is not so, however, in the Taconic system; there is a general barrenness of life and vitality, which is not accounted for, unless it is regarded as due to the period in which the rocks were deposited. Their rarity is not local; it is coextensive with a certain series of rocks. While the Silurian carries its characteristic fossils for more than a thousand miles, the Taconic system is equally comparatively barren for the same distance. Again, the scarcity of fossils can not be explained on the ground that the rocks have not been examined. This series of rocks have been under the eyes of geologists since 1817; they have been examined minutely in Rensselaer and Washington counties, N. Y., and Berkshire, Mass., and with more or less care over the whole area of western Vermont. A few fossils only have been discovered over this large area. Of the fossils which these rocks have furnished, marine vegetables are the most common, but they are limited to a few obscure species; the thickness of the bed in which they they occur is at least 2,000 feet. Graptolites rank next in numbers; they even exceed the marine plants in the number of species which have been found. In addition to the foregoing, there are three species of trilobites and some four or five of molusca.

The plants, it will be observed, occupy a wide and vertical space; it is the reverse of this with respect to the animals. The graptolites of the Hoosick roofing slate are confined to beds whose thickness scarcely exceeds two feet. The trilobites are quite limited also, and the little Staurograpsus is confined to the thickness of half an inch.*

I propose now to describe the fossils of this system in the following order: 1. The Marine vegetables; 2. Graptolites and the supposed foot-prints of Molusca, or, as some regard them, as animals allied to graptolites; 3. Molusca; and 4. Trilobites.

The Marine vegetables may be separated into three divisions: 1. The flat leafy expansions, using the term leafy in its ordinary meaning; 2. The elongated and rounded flattened chord like bodies lying in convoluted folds; 3. Stem like bodies usually short and rounded.

From the imperfect condition of all the vegetables in this system, it is impossible to classify and arrange them in a satisfactory manner. Hence, the most which can be done, is to give them some name by which they may be known. In my report of the agriculture of New York, I applied the common appellation fucoids, then in use. In Mr. Hall's report, two of those vegetables were named generically, Buthotrephis. I have no objection to the name; I shall therefore adopt it.

1. MARINE PLANTS.

BUTHOTREPHIS RIGIDA, *pl.* 2, *fig.* 1.

Fucoides rigida.

Frond rather narrow, branching and only slightly curved or flexuous. It occurs at numerous places in Rensselaer and Washington counties on the black flags and slates. It is much less common than the following.

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* If we assume the Hoosick roofing slates to be the repositories of the most ancient graptolites, and then trace the beds upwards and into the places where the graptolites and fucoids occur, we can not fail to be satisfied that these low forms of life and vitality are distributed through a much greater thickness of rock than I have stated in the text.

B. FLEXUOSA (*Hall*).

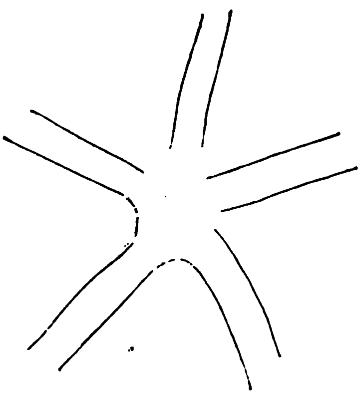
Fucoides Flexuosa (*Emmons*).

Frond wide, flexuous and branching, consisting of a very thin expansion of vegetable substance. The two species differ much in size; the first has much more substance, and appears stiff and rigid, and the frond is scarcely more than one half the breadth of the flexuosa, and is quite uniform in this respect. The flexuosa is eight or nine inches high, as the stem appears in the best preserved specimens, though the frond is often broken or interrupted by layers of slate. There is not much doubt that the two are distinct species.

I have observed two other kinds also in the rocks of Rensselaer—one with a very narrow frond, less than a line in width, with only a few branches, and another whose width is the same as the B. rigida, but had no branches on the part exposed, which was about six inches.

BUTHOTREPHIS ASTEROIDES (*Fitch*).

Fig. 23.



Frond stellate, having five branches radiating from a centre; Salem or black thin bedded slates.

Dr. Fitch refers this singular, though imperfect, organism to Mr. Hall's genus, Buthotrephis; perhaps correctly. It is, however, a remarkable form for a vegetable, and it may turn out to be one of the graptolites, inasmuch as discoveries looking that way have already been made. The edges are without cells or crenulations, but the extremities of the arms were much longer, it would seem, from the manner in which

* Transactions of Agricultural Society, 1849.

they terminate, than they appear at present on the specimen. Four or five of these singular plants, or graptolites, were observed on a single slab of slate two or three feet square.

Mr. Hall describes a vegetable fossil which occurs in the neighborhood of Union village and Salem. It is supposed to consist of fragments of succulent stems of plants, more or less compressed, but of a rounded form, and may be tubular or solid; they are about three inches long; they are referred to the new genus Palæophicus; see Palæontology N. Y., p. 263. It is the Palæophycus virgatus. Another variety or kind of stem was found several years ago in the green shales of Rensselaer county. The stem is twisted, see fig. 24, and may belong to the same genus or family as the foregoing.

Fig. 24.

These fragments are evidently casts of parts of vegetables, but their characters are too imperfect to enable the palæontologist to do more than refer them to the class of marine vegetables.

The rounded and slightly flattened chord-like fronds (if a frond), which are rarely if ever branched Professor McCoy has expressed the opinion that they are also marine plants, and has given them the generic name Palæochorda.

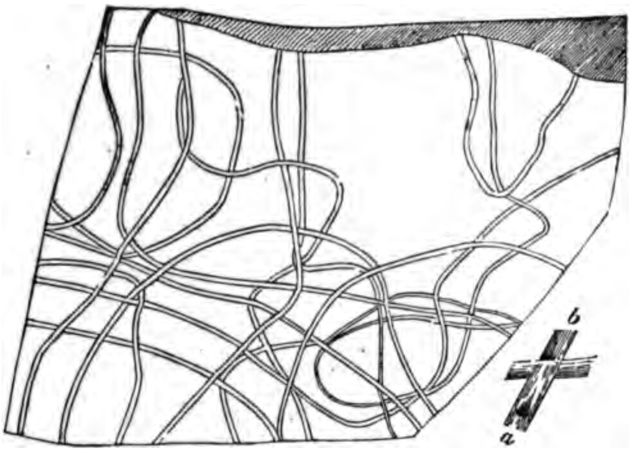
Generic char.—Frond, very long, cylindrical, chord-like. very slowly tapering at each end, surface smooth rarely dichotomous (*McCoy*).

PALÆOCHORDA MARINA, *pl. 2, fig.* 8.
Gordia marina (Emmons).
Helminthoidichnites marina (Fitch).

Frond very long, sinuous, slightly flattened by pressure, and one line in diameter. It occurs in flags at McArthur's quarry, in Easton, Washington county. A small part of the fossil appears in the figure.

PALÆOCHORDA TENUIS, *fig.* 25.*
Helminthoidichnites tenuis (Fitch).

Fig. 25.



The frond in its convolutions is similar to the marina, though rather more complicated; its diameter is about half a line.

Dr. Fitch has given the above name to this animal or plant, footprint or whatever it may be, on the ground that it is a footprint or mark of some marine worm. Dr. Fitch's specimens of the tenuis were found by him at Middle Granville, Washington county, N. Y.

* Transactions of the Agricultural Society, 1849.

2. GRAPTOLITES.

The discoveries which have recently been made respecting the relations which exist between the serrated arms or bodies usually known as Graptolites and a flat membranous central disk, and also the discoveries of other forms belonging to this family, will no doubt render it necessary to reclassify and rearrange the species so as to form and harmonize this curious family of animals. Without attempting, however, any thing of the kind at the present time, I shall satisfy myself with following Dr. H. B. Geinitz's arrangement as far as it has come to my knowledge. In regard to the affinities of the family, it seems that it partakes more of the asteroid than the hydroid type of Zoophites. But it may turn out that it contains species whose affinities may be in one case hydroid and in another asteroid; for it is certain that the central membranous body which has an asteroid type in one or two cases, is not always formed upon this plan.

Family—GRAPTOLITHINA (*Bronn*).

Genus 1. *Diplograpsus* (*McCoy*).

Serrations on both sides of the stem; the stem provided with an axis.

DIPLOGRAPSUS SECALINUS, *pl.* 1, *fig.* 11.

Graptolithus secalinus (*Hall*).

Fucoides secalinus (*Eaton*).

F. Simplex (*Emmons*).

Straight; serrations sharp or pointed, cells rather distant oblique to the axis; the serration equal in length to one-sixth or one-seventh of the width of the stem. The upper or young part of the stem is three-eighths of an inch wide, and the number of serrations is twenty-four to an inch. It narrows towards the base where the serrations are rather obtuse and more distant than those above, and is ten inches long as exposed upon the slate. It is confined to the Hoosick roofing slate.

Mr. Hall maintains that it is the G. pristis expanded, or widened by pressure. The intermediate varieties referred to, especially those upon the slate from this locality, belong to the inferior part of the stipe. The width of the species is variable, that is, from one-half to three-eighths of an inch, along the wider parts of the stem. Besides, the number of serrations differ from those of the pristis, the latter having thirty-six in the length of an inch and the former twenty-four; besides, the cells it will be seen from the figure which is of the natural size, differ entirely from those of the pristis. The differences, therefore, can not arise from any amount of pressure they have received; and, besides, this principle is inapplicable to the case.

D. RUGOSUS (n. s.), *pl.* 1, *fig.* 26.

Stem straight, thick, central column deeply and transversely corrugated and occupying all the space between the cells; the large cells appear to meet near the middle of the stem. In this species twenty cells are developed in an inch, and when they are removed by disintegration a broad depression is left, which gives a rugose appearance to the stem. It occurs at Parrottsville, Tennessee, in a black slate, which weathers to a soft light drab.

D. DISSIMILARIS (n. s.), *pl.* 1, *fig.* 5.

Straight; cells dissimilar on the different sides of the stem; on one side they open at right angles to the axis, on the other obliquely; axis nearer to the margin of the oblique serrations. The stem, excluding the tips of the serrations is 3-16 of an inch wide. The number of serrations or cells in an inch is twenty-six. The figure is taken from the base of the stem, and is the only part which has been found. It occurs in reddish slate, in Augusta county, Va.

D. CILIATUS (n. s.), *pl.* 1, *fig.* 19.

Straight, thin and ciliated; ciliæ, bulbous and jointed or transversely marked proceeding from the point of each serration;

serrations unequal, the intervening smaller serration rounded, the larger prolonged and run into the base of the ciliæ, axis distinct.

The specimen is imperfect, but probably, from the character of the column, it was free. The entire width of the column embracing the extended lateral ciliæ, is one-fourth of an inch, the membrane is rather less than one-eighth of an inch wide, the margins appear to be dissimilar. In another specimen the end is rounded and complete, and furnished like the sides with ciliæ. Found in Augusta county, Virginia.

D. OBLIQUIS (n. s.), *pl.* 1. *fig.* 22.

Straight, serrations turned obliquely outward, exposing the mouth of the cell.

The substance of the graptolite is olive green, thin and membranous. There are twenty-four cells in an inch. The sides are similar; axis, if any, concealed. Found in Augusta county, Virginia.

D. FOLIOSUS (n. s.), *pl.* 1, *fig.* 13.

Serrations prolonged, pointed and leaf like; expansions directed backwards or towards the base of the stipe at this part of the column; the upper end, the lengthened points, are directed upwards. The length of the free parts of the serrations is greater than the width of the column. This graptolite has forty cells in an inch, the substance green, or similar in color to the preceding. The cells appear as if they were arranged in a circular or spiral manner around an axis. It is found in soft, reddish slates in Augusta county, in Virginia.

GEN. MONOGRAPSUS.

Serrations confined to one edge of the stem; axis none.

M. ELEGANS, *pl.* 1, *fig.* 27.

Outer edge of the serrations straight and nearly parallel with the opposite edge; depth of the serration equals one-half of the width of the stipe. Fig. 14 enlarged. The width of the stipe is about one-sixteenth of an inch and there are twenty-four cells in an inch. The substance of the graptolite is green and coriaceous. This beautiful species occurs in Augusta county, Va., soft whitish slates.

M. RECTUS (n. s.), *pl.* 1, *fig.* 28.

Straight, serrations pointed, upper edge of a serration oblique to the axis of the stem. Width of a serration equals one-half of the width of the undivided part of the stem; width of the stem one-eighth of an inch, and twenty-two crenulations in an inch whose edges are perfectly straight and not curved so as to leave a curved space between the notches.

From the point of each crenulation, there runs an oblique ridge which meets a longitudinal one, the latter runs nearer the straight than the crenulated margin. This species occurs in Columbia county, in the Taconic shales and is closely allied to G. latus of McCoy.

GEN. CLADOGRAPSUS (n. s.)

Serrations or cells arranged on the outer edges of a branching stipe; axis none.

C. DISSIMILARIS (n. s.), *pl.* 1, *fig.* 15.

Outer edges of the stem dissimilar, serrations rounded, mouths of the cells appear to open at the base of the serrations on one side; on the other, at the apex.

The thin upper membrane when removed, discloses curved canals leading from the cells to the middle of stem. The substance of the graptolite is green and coriaceous.

C. INEQUALIS (n. s.)

Stipe very narrow and arcuate; serrations obsolete, being indicated by a waving edge; the cells open on the margin of the stipe just at the anterior edge of the faintly developed serration; the cell is an elongated oval, lying slightly oblique to the margin. The branches in this specimen are somewhat dissimilar, one being rather wider than the other. It is found at Parrottsville, in Tennessee, in a soft decomposing slate.

GLOSSOGRAPSUS (new genus).

Column free; thin membranaceous, ligulate, extremeties rounded, axis distinct.

G. CILIATUS (n. s.), *pl.* 1, *fig.* 25.

Straight linear crenulations faintly developed and prolonged into ciliæ, equal in length to the width of the ligulate body, ciliæ surrounding the whole body or membrane. The axis is prolonged beyond the membrane forming the column or stem. Length one inch. This graptolite seems to be one of the perfect forms under which this family is sometimes developed. It is well known that these serrated bodies, the Diplograpsus, etc., are but the mutilated parts of the animal, which radiate from a central membranous scolloped disk in some instances.

The Glossograpsus I regard as a perfect animal with its axis extended beyond the body; and this organ may serve to attach it to other bodies, or it may have floated freely. This form of axis often appears among other fragments of graptolites and hence like them may be regarded as a distinct species. The Diplograpsus, ciliatus and crinitus, may also belong to this sub family Glossograpsus, inasmuch as we know they are rounded at one extremity, but the character of the other is not determined and hence I have placed those in the genus Diplograpsus. The genus occurs in the dark colored shales of Columbia county, N. Y.

STAUROGRAPSUS (new genus), *pl.* 1 *fig.* 21.

Disk free, cruciform, arms four, dichotomous cells terminal, substance membranaceous, free and furnished with an axis.

S. dichotomous.

Disk, provided with four arms each, of which is divided near the extremity and forms a cell. Surface of the arms uneven and it is possible cells existed on the sides of the arms as well as at their extremities. This small and remarkable graptolite belongs to the asteroid type, but it preserves its relation to the graptolites by the presence of an axis which is visible where the branches are separated from the arms. The arms might have been reckoned as five instead of four, inasmuch as one divides just beyond the point where they cross. The largest of these asteroid graptolites is represented in the small figure by the side of the enlarged one. It was found in the black Taconic shales of Rensselaer county, N. Y.

Nemagrapsus (new genus).

Axis elongated and thread like, simple or compound branches round at the base and flattened at the extremities; cells appear to be arranged on the flattened part of the axis instead of the margin.

N. elegans (n. s.), *pl.* 1, *fig.* 6.

Axis arcuate and sending off numerous branches from the convex side, branches round where they leave the arcuate axis but expand upwards; margin even.

This species is extremely attenuate where the axis becomes flattened, and hence, through the particles of shale are fine, they break and obscure the continuity of the membrane. It is evident, however, there are no serrations upon either margin, and under the microscope the surface is slightly dotted so as to give the appearance of the mouth of cells. It is found in the Taconic slates of Columbia county, N. Y.

N. capilaris (n. s.), *pl.* 1. *fig.* 7.

Axis long, convoluted and furnished with a few short branches; under the microscope it appears annulate, but whether the rings are due to structure or to fractures, it is difficult to determine. The substance resembles the axis of a graptolite. It is, however, a veritable fossil, though I am unable to discover the cells proper to graptolites or other appendages for nutrition and growth. Taconic slates of Columbia county.

NEREOGRAPSUS (*Geinitz*).

"Biserial, the stem having no central axis or a very soft one."

N. JACKSONI, *pl.* 2, *fig.* 2.

Convolute, crenulations large, rounded and rather oval, the depression on each edge separating them, meeting in the middle on the line of axis. The body is half an inch wide and less than four crenulations in an inch. This large Nereograpsus occurs in the green talcose slates of Waterville, Me.

N. LOOMISI.

Convoluted, narrow crenulations, lanceolate terminating in an axis, or rounded ridge. There are twenty-eight crenulations in an inch. Waterville, Me.

N. DEWEYI, *pl.* 2, *fig.* 3.

Convoluted crenulations, small, rounded, and terminating in the middle of the stem, which on the side exposed produce a groove. Crenulations in an inch, twenty; width of the body one-eighth of an inch. This is one of the finest of the Nereites* in the series belonging to the Waterville slates.

* I have many doubts respecting the class to which the agents belonged which produced the singular impressions which have been regarded as foot prints at one time, and at another as belonging to a class of annelids, and which have received the name of Nereites, Myriantes, etc. But as Dr. Geinitz has seen the open mouths of cells, it is probable they should be placed in the family of graptolites.

N. GRACILIS, *pl.* 2, *fig.* 6.

Convoluted, crenulations numerous, narrow, scarcely pointed, extending to the middle of the body. The number of crenulations in an inch is twenty-two. Waterville, Me.

N. LANCEOLATA, *pl.* 2, *fig.* 4.

Convolute, centre of the body has a narrow ridge to which the lanceolate crenulations extend. The width of the body is five-eighths of an inch, and there are ten crenulations in an inch. Waterville, Me.

N. PUGNUS.

Convoluted, crenulations large, long, oval, extending to the middle. A part of the specimen is cylindrical and without crenulations.

In addition to the foregoing, there are two species of Myriantes, at the Waterville locality. These singular bodies are confined to a thickness of slate not exceeding four or five feet.

N. ROBUSTUS (n. s.), *pl.* 2, *fig.* 7.

Convoluted, crenulations nearly round, terminating in a strong, narrow ridge in the middle. There are about eight crenulations in an inch; body one-fourth of an inch wide. This Nereograpsus was found in the Taconic slates of Columbia county, N. Y., thus proving a similarity or parallelism with slates of Waterville, Me.

3. MOLUSCA.

Most of the molusca of this system belong to the family of Brachipods, all of which are so minute that it is difficult to discover their most important characters. Their shells are so extremely delicate and thin, that it is impossible to succeed in exposing those parts of the shell upon which their specific characters are founded if they are concealed in the rock. It is highly probable, therefore, that the references I have made may be incorrect. The figures of the forms and markings embrace all the characters which can be relied upon for their determination.

Genus Lingula.

L, striata, pl. 1, *fig.* 17 (n. s.)

Minute, oval, beak acute, concentric lines few, radiating lines distinct and numerous, comparatively wide at the extremity opposite the beak; it tapers rapidly to an acute beak, from a point about two-thirds the distance from the opposite extremity; it is extremely thin and attenuate; occurs in the white fragile shales of Augusta county, Va.

L. elliptica (n. s.)

Small, elliptic, extremities rather rounded, lines of growth faintly preserved, margins gently and regularly curved and alike; extremities subequal. The shell is extremely thin and delicate, and nearly one-fourth of an inch long. It occurs in the white fragile shales of Augusta county, Va.

Lingula, *pl.* 1, *fig.* 9.

In this fossil there is a departure from the common characters of this genus. The obliquity, however, of the figure, on a careful examination of the specimen, is rather exaggerated; the apex is subcentral, or rather the shell is inequilateral.

Gen. Orbicula.

O. excentrica (n. s.), *pl* 1, *fig.* 4.

Small, extremely thin, ovate, apex excentric and acute, rather elevated, rising from a nearly flat expanded border, the base of which is marked by a sharp ridge; concentric lines or lines of growth obsolete in front, distinct behind. Found in the white fragile shales of Augusta county, Va., associated with lingulas, graptolites, &c.

Gen. Obolus, *pl.* 1, *fig.* 10.

I refer to this genus, pl. 1, fig. 10. It has no teeth which can be discovered, but it is slightly inequilatral, and the groove for muscular attachment does not appear in any of the casts of this shell. The external form of the shell and its striæ are well preserved. It occurs in the whitish shales of Augusta county, Virginia.

Cypricardia, *pl.* 1, *fig.* 1.

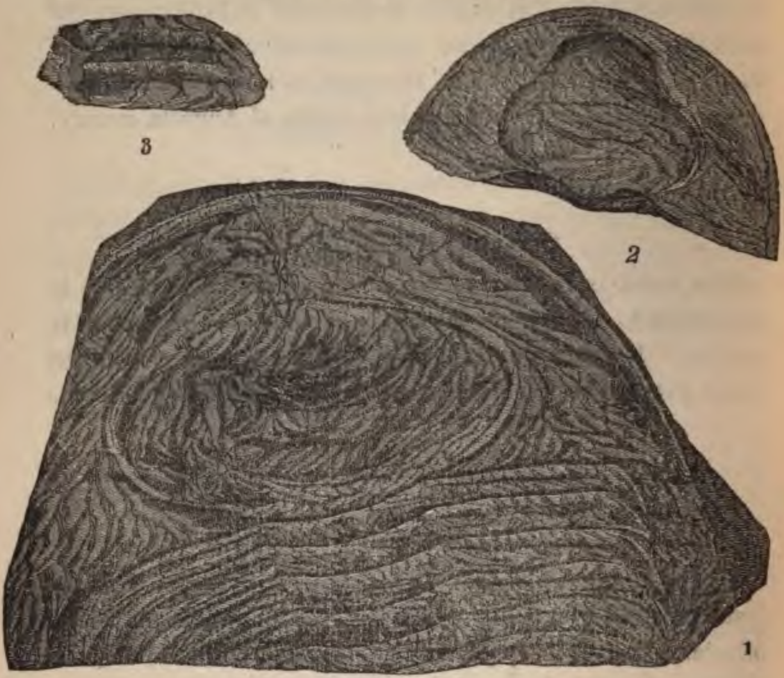
This fossil is referred to Cypricardia from its form. It is impossible to discover the essential characters in the teeth, if it has any. It had a very thin shell, and the lines of growth are rather prominent. A single muscular impression is preserved.

4. TRILOBITES.

The trilobites which have been discovered in the Taconic system, belong to a family which has been known in the lower Silurian rocks for many years. The species, however, are unknown in the Silurian period. They were first discovered in fragments, and hence there were reasons for difference of opinion respecting them. The Eliptocephalus and Atops were discovered in Washington county, N. Y., in dark-colored shales. I published figures in my reports of the foregoing genera, which I regarded as new at the time, and subsequent discoveries of specimens both species have confirmed the opinions which I then expressed. I have since discovered a minute trilobite in the shales, in Augusta county, Va., which I regard as older than those of Washington county. They are not, however, far removed from the same geological horizon. The condition of those in Washington county renders their characters somewhat obscure. They are not, however, distorted, but simply flattened, but not so much as to obliterate the stronger lines upon their surfaces.

1. Eliptocephalus asaphoides,* *pl.* 1, *fig.* 18.

Olenus asaphoides (*Hall*).



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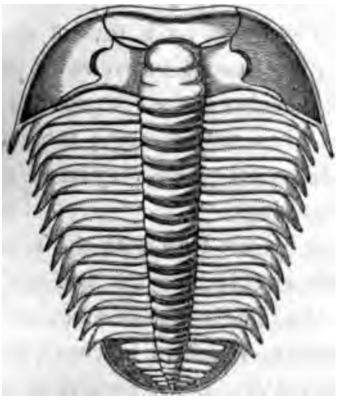
E. asaphoides.

Triangular, buckler, semi-eliptical, terminating posteriorly in elongated sharp shines. Suture indicated in part by an elliptical outline of the glabella, which in young individuals is lobed; eyes none, or entirely undistinguishable in the specimens. The number of ribs is unknown, but the number which can be distinguished is fourteen, which is evidently less than belongs to the species; pygidium unknown.

The Eliptocephalus has been referred to the genus Olenus by Mr. Hall. The ground upon which this reference is made is unquestionably insufficient, as the latter has been constituted.

* The genus Elipsocephalus was unknown to me at the time of the publication of the above; the name, from its similarity, is no doubt objectionable, but I am disposed to retain it for the present.

For comparison I have annexed a figure of the Olenus gibbosus Dalman, the one which is best known of the species. The buckler and its spines are much shorter, and from which the glabella is separated by a furrow. The length of the head of the Eliptocephalus is proportionally much greater than in the Olenus, to say nothing of the eyes; and the suture which, according to Mr. Hall, is similar to the Olenus, there is really no mark or line by which it can be determined, and probably if its direction in the specimen could have been seen, it would have been described, instead of saying in general terms that "it is as in the Olenus," for this is not an available description. The number of ribs is also greater. The figures, however, are placed side by side and may be compared by the student. I have also added a small figure of a Paradoxides, in which the comparative length of the head is much greater than in the Olenus.


O. gibbosus.


P. Bohemicus.

2. ATOPS TRILINEATUS, *pl.* 1, *fig.* 16.

Calymene Beckii (*Hall*).

Crust granulated, cephalic shield semicircular, with its anterior and lateral edges turned upwards; posterior angles rounded, facial suture, beginning at the outer angle of the cephalic shield, and runs nearly parallel with the anterior margin to the middle lobe, when it turns at a right angle and runs parallel with that lobe; eyes undistinguishable, body composed of seventeen or eighteen rings, narrowing very gradually to the caudal extremity; pygidum a flat expansion of the crust and is provided with a single ring; axis narrower than the lateral lobes, rings seventeen, each of which is separated by a groove about as wide as the rings. Axis armed by a row of short spines; lateral lobes provided with a row of tubercles or prominences along the median line; margins of the rib groove run parallel as far as the tubercle, when they diverge; tubercles become obsolete towards the tail; caudal shield very small and provided with one, or at most two rings.

This fossil has been confounded by Mr. Hall with the Triarthrus Beckii, Greene, or Calymene Beckii. He has been misled by the row of short spines along the middle lobe or axis, which it is well known exist in that species. It differs, however, from the Triarthrus in every other character; in the number of abdominal and caudal rings, the proportions of the subdivisions of the head, the granulations of the integuments and the row of tubercles along the lateral lobes. So palpably different were the heads of the Atops and Triarthrus, that a committee of the American association decided they were different from the heads alone: and since this decision was made the specimen figured has been found, which sets the question at rest.

Both of the foregoing are found at Reynolds, about seven miles north of Union Village, Washington county, N. Y., in the shales of the Taconic system.

3. Microdiscus (new genus), *pl.* 1, *fig.* 8.

Microdiscus quadricostatus.

Minute, oval, middle lobe of the cephalic shield strongly developed; ribs of the body or abdomen, four; of the tail, four or five. The form of the cephalic shield is only obscurely indicated; the size of this trilobite is shown in the small figure. It is found in the white fragile shales of Augusta county, Va., associated with minute moluscas and graptolites.

GENERAL DISTRIBUTION OF THE TACONIC SYSTEM IN THE UNITED STATES.

§ 55. The Taconic system forms a belt on each side of the Blue ridge. On the west side the belt is continuous from Canada East to Georgia. On the east side, the belt is wider at certain places than on the west side, but its continuity is broken and I am inclined to believe it never embraces rocks which belong to the upper division. It is more distinct in North Carolina and Virginia than in Maryland or in any of the states farther north. In Rhode Island and Maine it occurs in areas of small extent. The quartz and its associated talcose slate is the base of the system, and constitutes the largest part of the lower series. On the east side of the Blue ridge the Silurian system is unknown, and hence we have no data by which we can directly determine the epoch of this sedimentary belt, and hence we are obliged to rely upon lithological characters for its determination, and as these agree in the main with those upon the west side, which are overlaid by the rocks of the Silurian system, we refer them accordingly to the same period. The only sediments which overlie the Taconic system, are those belonging to Professor Rodgers' middle secondary period, and hence from the time the lower Taconic were formed up to the middle secondary period, the eastern side of the Blue ridge was dry land, or rather that section which is now known as the Blue ridge. At Haverstraw, the new red or middle secondary is formed of materials derived in part from the lower limestone of the Taconic system. On the west side of the Blue ridge, the lower rocks, quartz, talcose slates and limestones have a strike of N. 60° E. if reckoned on the data furnished by the southern extremities of the series. Thus from the southwest corner of North Carolina, in Cherokee county, the line of outcrop of the quartz rock as far north as Harpers ferry, on the Potomac, the strike is N. 60° E. In Massachusetts and Vermont the strike of the same rocks is nearly north and south. The width of the belt is greatest between Troy, N. Y., and Adams, Mass., where on an air line it is about thirty-five miles wide, though it is about as wide when measured on a line from Abingdon, Va., to Taylorsville, Tenn. The Taconic rocks are divided on the Hudson river by the highlands. The western or upper division crosses the river near Poughkeepsie. They appear on the west bank about five miles above Newburgh, and from this point traverse the county of Orange. It is near Poughkeepsie that the series begins to be deflected to the west, and in crossing the northern part of New Jersey into Pennsylvania, the series has passed into the same strike that it has between the south-west corner of North Carolina and Harpers ferry. I have not traced it farther south than north bounds of Georgia. I have examined and proved the system in Canada and Maine, and am able therefore to state from personal observation that it extends at least 1200 miles in lines parallel with the Blue ridge.

In Michigan, in the Lake Superior region, on the north shore of Lake Huron, the Taconic system is largely developed. It has been briefly described by Mr. Logan, and has also received the name Azoic system by Messrs. Forster & Whitney, United States geologists. It was, however, first noticed by the lamented Houghton. I alluded briefly in my geological report to a verbal communication which was made me, expecting, however, a fuller account of the northwestern series at a future time. I have received a series of rocks from the northwestern region, which furnish me all the lithological characteristics of the series as it is developed in Washington and Rensselaer counties, N. Y.

Having never seen the Taconic system in the northwest, I shall content myself with what I have said in regard to it. Of its existence then, in the region specified, I have never entertained a doubt since I received the information I have already stated.

As facts have accumulated from time to time, I have become satisfied that the Taconic system will be recognized in other parts of the United States. It would, however be premature to attempt to identify it in sections which have been imperfectly explored.

Former extent of the lower Silurian eastward of the Hudson. The existence of insulated outliers of the lower Silurian system, some fifteen or twenty miles east of the continuous masses at the Cohoes, near Waterford, indicate that there was once a continuous sheet of them. Those isolated masses usually occur upon the knobs and ridges, or upon their slopes. In the valley of the Hoosick, at Hoosick falls, the ridge of the calciferous sandstone is some four or five miles long, and is well characterized by its fossils. The ridge west of Hoosick has escaped denudation in consequence probably of its being upon the eastern slope, for the northwest sides were exposed more directly to the action of denuding forces; it was the *struck side.* The effect of denudation furnishes important facts respecting the relative age and position of the two systems. Thus, in many places the Taconic rocks are swept perfectly clean, and are laid bare, while a knob or ridge in the line of strike is capped with the remains of lower Silurian rocks. These patches or remains of Silurian rocks differ greatly in thickness, a difference which arises partly from activity of the denuding force. But it is also probable that the sheet of the overspreading lower Silurian was never as thick upon the eastern outskirts of the system, as in the Mohawk valley, and besides the limestones which are well defined there, are in this region of outliers feebly represented and poorly defined. I have found at Greenbush the fossils of the calciferous sandstone, the Chazy, birdseye and Trenton limestones. Yet the two predominant masses are the calciferous rous and Trenton; and yet there are small masses of limestone which are scarcely determinable upon the spot which contains the Maclurea and Fucoides demissus of Conrad, the characteristic fossil of the birdseye limestone. The dip of the outliers of the Silurian limestones is exceedingly variable. At Hoosick, the dip of the calciferous sandstone coincides very nearly with the slate upon which it rests. It is an instance where, if the junction of the two systems could not be seen, it would be maintained that the two are conformable, and hence would lead the observer, as similar instances have already proved, to adopt the conclusion that being conformable masses, they belong to the same period.

§ 56. *Is it necessary to assume that the gneiss, mica slate and hornblende or the laminated pyrocrystalline rocks are altered sediments?*

The discussion of this question involves that of another, whether we have evidence that the Taconic system contains the sedimentary base I have claimed for it. Without debating this point at this time, I remark, that inasmuch as we are unable to recognize in the oldest palæozoic strata gradations into the laminated pyroctystalline rocks, and as it has been shown that there is a series of sediments far below any trace of an organism, it may well be inquired if they are not in that condition which may be rationally expected, for representing the oldest sediments upon the globe. The laminated do not, in any part of the globe, pass into the oldest sediments. Geologists do not find pebbles, obscurely defined, in laminated rocks, or other phenomena, which indicate that they were originally sediments. The possibility of changing sediments into laminated masses, in which all traces of the aqueous origin shall disappear and become obliterated, will not be denied. But on the ground, that of possibility alone, is it necessary to assume that the laminated rocks were originally sediments? seeing, too, there are no intermediate masses which prove a passage from the sedimentary to the laminated rocks, can it not be proved that sediments have a beginning in a clear and well defined base which forms also a distinct boundary between what we know to be sediments and those rocks whose aqueous origin is only assumed, because there are forces in existence which can change sediments into the likeness of the laminated masses. It seems to me unnecessary, therefore, to regard the laminated rocks as altered sediments.

Is the Taconic system established on facts and principles which are received and acknowledged by geologists of authority?

For the benefit of the student, I shall copy the views of Mr. Murchison as he has expressed them in a communication to the Geological Society of London, and which will be found in its proceedings, vol. 3, p. 38. Mr. Murchison says:

"That it is not by finding, after several years of elaborate research, a few undescribed and rare British palæozoic forms, that the age of rocks can be determined. The true tests are the order of superposition, and the common prevalent fossil types; for, if amid forms peculiar to one or two localities, the prevailing typical shells of a previously named group should occur in lower or thicker strata, or, if the band in question can be followed into other tracts, where the usual types abound, the point is determined."

The doctrine contained in the foregoing quotation is evidently this, that where there is no superposition of rocks, and where the fossils throughout a series of beds belong to the prevalent fossil types, we have the proof that the system is one system, though it may contain a few new and unknown species which are discovered by diligent search.

But, then, the doctrine is equally clear that if we find overlying rocks of one system and the fossil types do not belong to the common typical forms, but differ as a whole, then we are warranted in regarding two series thus distinguished, as belonging to different systems or different epochs. The foregoing principles form the basis upon which my convictions have rested. It is, first, upon superposition, as exhibited at Hoosick, Greenbush, Bald mountain, Galesville, North Granville, Snake mountain, Highgate, at Sharpshins, and at many other places where the relations are the same, that prove what I have contended for the Taconic system in all its length and breadth. But superadded to this, I have shown that the species of fossils differ also from the Silurian types; that is, the species are different, and they are not intermingled with the well known Silurian types, for of the latter none are yet known, and this last is a signifi-

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cant one. If the beds which contain fossils contain none which are Silurian, what are we to infer, especially if this is a general fact; certainly, that if fossils are to have weight in determinations of this kind, it goes strongly against the doctrine that the series is Silurian. If it is an established doctrine, that rocks which are separated in vertical space and also in time, will be characterized by different fossils, then that doctrine should govern our opinions. If we can account for the absence of fossils in a fossiliferous series, on established principles, their absence becomes of no account in questions of age; but when the fact is general, and it prevails for a thousand miles, it becomes significant. A fossil period will furnish fossils somewhere on lines so extended, and if on lines thus extended, they are not found, then we are justified in the belief that the period was not one of life and vitality. The lower part of the Taconic rocks belong to this period; they are, every where, so far as discoveries have yet been made, devoid of fossils.

The Taconic system rests, then, on the following points:

1. Its series, divided into groups, are physically unlike the lower Silurian series.

2. It supports unconformably at numerous places the lower Silurian rocks.

3. It is a vital system, having been deposited during the period when organisms existed.

4. As a natural history system, it is unlike the lower Silurian, first, in containing fossils yet unknown in the lower Silurian, and, second, in the absence of the typical forms which are prevalent in the lower Silurian.

5. In the Taconic system we have the palæozoic and sedimentary bases; the former comes in far above the latter, or at a period long subsequent to the time when deposits began to be formed.

6. The Taconic system carries us back many stages farther in time when life gave vitality to its waters than the Silurian. It represents a period vastly longer though it may occupy a less superficial area.

THE SILURIAN SYSTEM.

IT IS WIDELY EXTENDED IN NORTH AMERICA. ITS PHYSICAL FEATURES ONLY SLIGHTLY DISTURBED BY IGNEOUS FORCES. THE CHAIN OF ORGANIC BEINGS IS THEREFORE THE MORE PERFECT.

§ 1. The Silurian, which fills so large a volume in geologic history in Europe, seems to be still more full and complete in America. It extends from Canada on the north to Alabama in the south. The northern highlands lying between the St. Lawrence and Lake Champlain bulge up in an irregular dome, from which it is thrown off in every direction, but in a more important sense, in two directions; the first, towards the northeast; and the second, towards the southwest.

The dip of the rocks on the northeast side, indicates the existence of a great basin widely spread out in this direction which might be called the Laurentine basin of this system. Following the dip to the southwest, the indications are equally clear, that in this direction also there is another basin extending over an immense area, having its southeastern base in the Appallachian mountains, and hence may be called the Appallachian basin of the Silurian system.

The rough measurement over this anticlinal which separates these great basins of Silurian rocks which extend on the one side far to the northeast, and on the other to the southwest, gives at least twenty degrees of latitude. Following the base of this system from the northern extremity of Lake Champlain to the St. Lawrence and then tracing its course upon the irregular borders of the great lakes to the waters of the Mississippi, above the Falls of St. Anthony, it has a basal line nearly 1500 miles long.

This vast extent of base, taken in connection with the developments of the system northeast or southwest, or on both sides of the anticlinal shows the magnificent scale upon which this system was laid down in North America.

§ 2. When we take into account the great extent of the system as stated in the foregoing paragraphs, it will no doubt be regarded as a remarkable fact, that over these wide areas it is comparatively unbroken by igneous injections and the regular succession rarely broken up or displaced by outbursts of pyro-crystalline rocks; the sediments therefore, when examined on a large scale, seem to have been quietly deposited, or their orderly accumulation scarcely interrupted. This freedom from breaks and interpolated igneous masses, has an important bearing upon the existing regularity in the arrangement or succession of the organic stages which belong to this system; and from these favorable conditions for the prolongation or preservation of life, we may attribute the more perfect representation of these stages during the palæozoic period. The two facts seem to harmonize so well, that they may be connected together or related to each other as cause and effect. From the foregoing, it will probably follow also, that the time when important species were created may be more exactly determined, as well as their derivation and time of their disappearance or extinction. If so, the palæozoic period will be more interesting, as it will furnish a fuller and more complete history of life and organizations, especially when taken in connection with the vast area over which they are spread, furnishing thereby a more varied and more favorable condition for its manifold developments. Its natural history will be far more complete and full, and its connections preserved better than it possibly could have been, had this period been remarkable for extensive dislocations and disturbances.

SUBDIVISIONS OF THE SILURIAN SYSTEM.

§ 3. The present twofold division of the Silurian system gives the student all the advantages and facilities for investigation which are necessary and essential to his purpose, or which could be secured by a farther subdivision. The established divisions are *upper** and *lower*. The latter embraces the old geographical division of New York, the Champlain group. With this modification, the Oneida conglomerate should be removed to the base of the upper division, or upper Silurian.

The lower Silurian, to which I have had so many occasions to refer, includes the following rocks: Potsdam sandstone, calciferous sandstone, Chazy limestone, Black river limestone, Trenton limestone, Utica slate, Lorraine shales and sandstones. The last in this subdivision, has been frequently called Hudson river group. The only reason assigned for the name was, that this subdivision presented certain peculiarities arising from a disturbance it had suffered along the Hudson river. The Hudson river region, however, presents no facilities for the examination of the upper part of the lower Silurian; it is only in Lorraine or Pulaski, and the neighborhood of Romé, in New York, that this part of the series can be examined satisfactorily.

* The writer, while engaged in the New York survey, proposed the following geographical divisions, or groups, viz: Champlain, Ontario, Helderberg, Erie and Cattskill, or old red sandstone group. These groups were not considered at the time as good Natural History divisions, but as a large number of rocks were to be described, it became necessary to propose subdivisions so as to introduce some method into reports. The Champlain and Erie groups could be recommended, on the ground that they were natural, at least in part; the Ontario group is also a natural group.

It has frequently been intimated that the subdivision of the New York rocks was too minute, and also founded on unessential characters, as well as those of an unequal value. The reason for this minute division was, that all the rocks named contained respectively many fossils which seemed to be confined to these, and hence it facilitated very materially a reference in each case; it saved an indirect reference and circumlocution.

LOWER SILURIAN SYSTEM.

Its members and its distribution; compositoin in different parts of the Union; rocks which seem to be unimportant from the limited space they occupy, contain important memorials of the past; points of view under which rocks should be examined.

§ 4. The lower Silurian palæozoics seem to be fully represented in New York and along the eastern rim of the great Appalachian basin as far southward as Alabama. In New York and Canada the following rocks may be regarded as their representatives, viz. Potsdam sandstone, calciferous sandrock, Chazy limstone, birdseye limestone, Black river limestone, Trenton limestone, Utica slate, Lorraine shales, terminating in a thick bedded gray or greenish gray sandstone. The foregoing rocks are not of equal value or equally important, considered simply as members of a physical group. This arises from two or more causes; the first of which is the limited space they occupy when present; the second, from their frequent absence, and lastly, when regarded as the repository of fossils, they contain less which is important than their associates. Thus, the Black river limestone rarely exceeds fifteen feet in thickness, but as it furnishes at one or two places, and perhaps more, a fine black marble, it becomes necessary to give it a name and place in the series. So the birdseye rarely exceeds thirty feet, yet its fossils and the excellent lime which it makes, render it necessary to speak of it as a distinct rock. The Utica slate is scarcely recognizable in the western states, yet in New York it exists in a distinct mass, at least seventy-five feet thick.

To the foregoing list of rocks it may be proper to state in this place, that in Wythe county, Va., and other parts of the southwest, slates and sandstone are important masses, as they are intercalated between the Trenton limestone and the Lorraine shales. This rock is a soft, reddish sandstone, mottled with green spots, but contains narrow calcareous bands from ten to eighteen inches thick, which are heavily loaded with fossils, which, as a whole, resemble the Lorraine shales. It is from 150 to 200 feet thick, and near its junction with the Trenton limestone has beds of conglomerate. I deem it useful to notice even those rocks which appear unimportant, as masses, when placed by the side of those which are several hundred feet thick. Those items of information which may be gathered from all points, and upon which the geologist makes up a full statement of geologic history, become important in filling up gaps and intervals both in time and space.

In consequence of the interest which invests the study of the palæozoa and the rocks which contain them, their meteorological characters should not be neglected, as they usually are, excepting in those points which are general, or which are recognized at a glance, the minor characteristics being regarded as useless in geological reasoning. It is, however, certainly better to examine, with a good degree of minuteness, the physical constitution of all the rocks of a group. It puts us in possession of data which may be employed in interpreting an important class of phenomena which have their influence upon the organisms which they contain, and moreover they throw light upon those meteorological conditions which prevailed during the time of their deposition.

Rocks may be examined and studied, first: as to their composition and the variation which at distant points change with the circumstances under which they were deposited; and secondly, the physical and chemical changes which they have undergone since they were consolidated; and thirdly, as the repositories of the metals which belong to the period of their formation as fossiliferous masses, which contain the most valuable memorials of change and progress which the crust of the earth has been undergoing in past ages.

INDIVIDUAL AND SPECIAL CHARACTERISTICS OF THE LOWER SILURIAN ROCKS.

§ 5. *Potsdam sandstone.*—Formation No. 1, of Prof. Rodgers.—Considered as the base of this system, it is suggestive of many inquiries with respect to the period which it represents at its beginning. Its composition is uniformly silicious, but in texture and color it is variable. At Potsdam it is a firm and even bedded, even grained, yellowish brown sandstone. In other places in New York, as at Mooers and Moira on the Provincial line, it is equally even grained and even bedded, but is white and friable, especially at Mooers. At Chazy it is a deep red rock, and contains many particles of undecomposed magnetic iron, and at Whitehall, Keeseville, Corinth and Hammond it is white or brownish white, but is more or less vitreous. At Burlington and Charlotte, Vt., it is a jointed chocolate colored flagging stone; in other places in the valley of Champlain and Hudson river, it is a brown and rough bedded mass and quite thin. In Canada east, at the Falls of Montmorenci, it is a coarse sandstone loose in texture, and stained with carbonate of copper. It here reposes on gneiss and is not more than ten feet thick.

In Iowa and Wisconsin it is a light colored, soft sandstone, intercalated with argillaceous, and argillo-calcareous deposits. It is therefore variable in its coherence.

In Virginia, and the southwest part of the union it is also a light colored sandstone with an open texture, rarely vitreous, but its upper beds alternate with calcareous layers of considerable thickness, as at the head waters of the Holstein and Clinch rivers.

At many places its inferior beds are pebbly and very coarse, but they are by no means always present, and the gneiss on which it reposes seems to be changed gradually and imperceptibly into a fine sandstone with thin beds of mica between the strata, as at Corinth and Whitehall. The Potsdam sandstone, although in northern New York it is 400 feet thick, is sometimes absent, as at Little falls, where the calciferous sandstone reposes upon the primary rocks. It often thins out rapidly as at Whitehall and Comstock's landing, where in two or three miles, and even less, a mass two or three hundred feet thick gives place to the next rock above.

In the interior of the region lying between Lake Michigan and the Mississippi river, the Potsdam sandstone crops out from beneath the calciferous sandstone. It would be traversed obliquely in crossing from Green bay to Prairie du Chien. On both sides of the Mississippi and the lake, it is overlaid by the succeeding rocks, though upon the Mississippi and St. Croix, the latter is cut through by numerous streams down to the sandstone; the Potsdam sandstone of Wisconsin and St. Croix is about 500 feet thick; the upper mass is a white friable sandstone. It covers a large area, but its extent has not been determined, in consequence of a deep covering of drift towards the southern shore of Lake Superior. This great mass of sandstone is fossiliferous. It is so even near its base; Dr. Owen having discovered five or six beds or strata containing trilobites, lingulas, obolus, and crinoids, and bivalves belonging to the family of the Orthidæ. This mass of sandstone is probably nearly continuous with that upon the north shores of Lake Huron, where it rests unconformably upon the Taconic system; and where, too, the latter system is the repository of copper, and is traversed by traps and porphyries, as in North Carolina.

I have already alluded to the position of the Potsdam sandstone, in the southwestern part of Virginia, and at certain intermediate points; and from what has been said it will be inferred that it does not immediately flank the Blue ridge on the west, but occupies a position, even in the latter state, many miles from the base of this range; thus in the great valley west of the Blue ridge, it is some twelve or fifteen miles from its base. In Augusta county, about one, or one and a half miles west of Staunton, the Potsdam sandstone crops out from beneath the overlying calciferous sandstone, and in going west to the Buffalo gap, the series is lower Silurian, and is repeated twice or three times, the Potsdam being brought to the surface in each repetition. The Trenton limestone, fully identified by its fossils, crops out for the last time nine miles west of Staunton and one mile east of the Buffalo gap. This rock is reddish white and reddish brown, and usually alternates once or twice with the calciferous, or rather, beds of a silicious limestone occur, interstratified with beds of sandstone. One of the places where the Potsdam will be found west of Staunton, is at the western slope of a ridge, just beyond West View, about six miles west of Staunton.

This rock throughout this region, both to the northeast and southwest is not a vitrified quartz, but a sandstone more or less granular and sometimes pebbly. So also in Wythe county, Va., the Potsdam sandstone crops out near the base of Little Brushy mountain, some six or eight miles west of Iron mountain whose rocks belong to the Taconic system. Here, then, it is still farther removed to the west of the Blue ridge. But it should be distinctly stated that this rock appears at the base of the Walker and Garden mountains in its true geological relations. I am, however, unacquainted with it farther west and southwest than Jeffersonville, Tazewell county, on the head waters of the Clinch river.

From the foregoing statement of facts, it will be perceived that we are not to look for the base of the Silurian system upon the flanks of the Blue ridge, or at its base; it no where, I believe, touches this range; and even the South mountain, where it comes up into Pennsylvania, has no connection with the Silurian base. I have already shown that, at Harper's ferry, the quartz rock is not Silurian, but belongs to the Taconic system.

I have alluded to the Trenton limestone, one mile east of the Buffalo gap of the North mountain. The Potsdam is not brought up to view between the Trenton and this broken range near the road, but it may probably be found not far from this place northeast or southwest. The lower Silurian, consisting of the Trenton and the inferior members seem to overlie the Clinton group, a group which constitute the North mountain at the gap, and I mention this for the purpose of saying that the lower Silurian holds here the same relation to the superior rocks, that the Taconic rocks do at the Queen's Knob, in Wythe county; and also along the range of Little Brushy mountain.

The position of the Potsdam sandstone in its southwestern prolongation may be very accurately fixed by conceiving it to lie near the eastern flank of Little Brushy, in Wythe county, and North mountain, in Augusta county, Va. It will occupy the western side of the great limestone valley of Virginia, following the westward deflection of the Appallachians as they approach the state of Tennessee. But the range of the Potsdam is its most easterly one. It appears still farther west, as I have stated, at Jeffersonville, in Tazewell county, and hence, it will probably be found in all the great valleys at the base of the mountains which traverse Virginia. It holds also the same relations in Tennessee, and will be found by tracing from Virginia its lines of outcrop in the direction of the strike of the lower Silurian. It is everywhere a sandstone, that is, it is not vitrified, but more or less porous and is also more or less interstratified with calcareous beds in its upper part.

§ 6. *Palæozoa of the Potsdam sandstone.*—The Potsdam sandstone had been examined with considerable interest, at several places which appeared favorable for the preservation of fossils, without success. The writer, however, succeeded in finding lingulas in the first instance, at Birmingham, in Essex county. They occur in the rock which forms a mural precipice on the Ausable, at a place known as the High Bridge. The rock is scarcely disturbed, the sandstone itself is somewhat vitreous and thin bedded, and between the beds a thin slaty matter intervenes, upon which the lingulas are found. The dark slaty matter is just sufficient to give a dark stripe to the layer. These fossils are distributed through a thickness of seventy feet. Since this discovery many other fossils have been found; indeed they have become so numerous that it may be regarded as rather rich in organic remains. Near its junction with the next rock marine plants are quite abundant. Trilobites, crinoids, Orthidæ, etc., are among the fossils of this rock; thus, the base of the Silurian system has proved to be fossiliferous at the lowest beds. It is particularly so where carbonate of lime enters even in a small quantity into its composition. The fossils will be described in another part of the work.

From what has been said, it will be perceived that it is widely distributed; that it is quite uniform in its composition. In northern New York it is harder and more vitreous than at the west and southwest.

§ 7. *Economical uses of the Potsdam sandstone.*—The typical form of the rock occurs at Potsdam, where it is very even bedded, breaking with facility into pieces of almost any size, even of the size of a brick. At Moira and Malone, N. Y., it is also even bedded and suitable for flags and for building. Houses which are constructed of this rock look remarkably neat and finished. It has an advantage over the compact limestones, that moisture is not condensed upon the inner surface of the walls. The rock is also suitable for glass making at many localities. A white, friable variety suitable for this purpose is found at Moira, in Clinton county, N. Y.

The fine grained varieties usually stand the fire remarkably well, and hence have been rather largely employed for the hearths of furnaces.

§ 8. *Calciferous sandstones.*—Formation No. 2, of Messrs. Rogers' Geo. Rep.—This rock has a variable composition. The name was first applied by Mr. Eaton to a rock consisting of carbonate of lime and fine grains of sand so intimately blended that it appeared homogeneous. This is a gray rock, and the grains of limestone give a sparkling surface. It always contains small masses of calcite, or calc spar, intimately blended in the mass. Subsequent examination has proved that this rock passed into a pure carbonate of lime, sometimes gray, and at other times black. In many places it contains beds of magnesian limestone and a small quantity of iron.

There are, therefore, when composition is regarded, three varieties; the silicious, the magnesian and the pure carbonate of lime. Of course there are intermediate grades of composition.

Leaving out of view its composition and turning to its structure, it is proved to pass from compact to granular; the granular becomes porous, and frequently this variety has cavities which are lined with crystals of quartz and calcareous spar.

Instead, however, of a cavity lined with numerous points of crystals, a single perfect crystal of limpid quartz will be found nearly filling the space. These cavities also contain a solid coal-like substance, in the form of globules and drops. The composition of this substance has never been determined by analysis. It exfoliates in fine particles in the flame of a candle, leaving a smooth, conchoidal surface; but it neither burns nor exhales a bituminous odor. The substance is sometimes contained in the quartz crystals and in the calc spar also; the quartz is also sometimes in globules. The structure of the rock is often oolitic; the rounded grains are usually the size of mustard seed, but sometimes again they are six or eight inches in diameter, when the structure is regarded rather as concretionary than oolitic. Strata, sometimes six or eight thick, are concretionary, forming alternating beds with those of the ordinary kind. The quartz, however, is not always in grains or in crystals, but is more commonly cherty and frequently very abundant in the lower beds. This rock, as it usually occurs, is dull and would not admit of a polish. The dullness is due to the presence of a yellowish earthy sediment between the strata. It is a tough rock, especially when thick bedded, or when it passes into the Potsdam sandstone.

At Chazy the following strata occur in a series of beds, beginning with the lowest:

1. Silico-calcareous beds more or less interspersed with sparry

masses, thirty to thirty-five feet; fossils rare and more or less cherty.

2. Crinoidal mass composed almost entirely of disjointed and broken columns of encrinites in which plates of the cistidea may be recognized, twenty feet.

3. A dull, gray, earthy mass, ten feet, without fossils, and passing into oolitic beds.

4. Another crinoidal mass similar to the first, though its color is of a brighter red, 15 feet.

5. A mass more earthy and silicious, and more massive; it contains the Isotelus aud Illænus, twenty feet.

6. Mineral character similar to the foregoing; the fossils are mostly Orthidæ, of which individuals two or three species are very numerous.

7. Red crinoidal mass, with less earthy matter, and is susceptible of a fine polish; fifteen feet thick.

8. Drab colored, thin bedded, magnesian beds, suitable for hydraulic lime. The drab colored layers rarely contain fossils; at Glenn's falls, however, they contain fucoids. Towards the top of the rock it is blue and frequently cherty and oolitic with concretionary beds. These upper masses are variable in thickness at different places, but usually they are from 20 to 30 feet thick.

In the state of Wisconsin, the calciferous sandstone is well developed, according to Dr. Owens's report. Upon the Mississippi and other western rivers, it is the rock which gives character to the landscapes. It rises in castellated terraces, which look like ruined structures of by gone ages. It rises up in steep mural precipices from the water's edge or from a fine slope of luxuriant sward, clothed with grass and showy flowers.

These steep escapements are composed of jointed columns, which stand out from the main mass in strong relief, a structure which is due in the main to the wear of atmospheric agencies, and not unfrequently to the direct undermining effects of water.

This rock, in Wisconsin, is surmounted by a white sandstone, which has received the local name of St. Peter's sandstone. It differs from the same rock at the southwest only in being thicker and exposed more prominently to view. It is superimposed upon the inferior beds; it stands prominently out in the mural escapements of the St. Peter's river. It is not proposed to separate it from the calciferous. It merely forms one of its prominent subdivisions, and is noted as No. C, of the calciferous sandstone, of which it is regarded as the terminal member.

In the southwest, or in Virginia, Tennessee and Kentucky, the calciferous sandstone at Shannon's scarcely differs from that of northern NewYork. At the western foot of Walker's mountain the calciferous includes a sandstone which comes in near the top of the series, and is analagous to the St. Peter's sandstones of the northwest.

Chemical Composition of the Rock.

§ 9. Dr. Owen gives the following result derived from Mr. Norwood's analysis of this rock. It is the magnesian variety, as the analysis shows:

	1. From Lake Pepin.	2, Oolitic, from Winnebago.
Carbonate of Lime,	52·0	50·93
Carb'te of Magnesia,	42·2	41·13
Insoluble Earthy Matter,	4·3	
Oxide of Iron and Alumina,	0·9	1·74
Water and loss,	0·6	0·86
	100·0	100·00

The average thickness of the calciferous sandstone is about 300 feet in New York.

At the mouths of Vermilion and Wisconsin rivers, Dr. Owen states its thickness at 225 feet, and the St. Peter's sandstone at from forty to ninety feet.

There is a peculiar variety of the foregoing rock, which, although it comes under the concretionary kinds, yet requires a few additional remarks in order to convey a correct idea of its condition. It is a lumpy, concretionary mass, similar to a breccia; indeed the lumps are frequently so much angulated that it may be mistaken for the latter rock. Still, it must be regarded as concretionary, as its most common condition is that of a concretionary mass. It occupies a place near the bottom of the series.

The only real breccia or brecciated conglomerate which has fallen under my notice is upon the Montmorenci, in Canada East, where these beds are made up in part of boulders.

The concretionary kind which I have described occur at Greenbush Cantonement hill, one mile east of Troy, the gorge at Highgate, Vt., and at other places on the east side of Lake Champlain.

§ 10. *Distribution of the calciferous sandstone.*—The calciferous sandstone is more persistent than the Potsdam sandstone, hence, it is the base of the Silurian system when the latter is absent. It surrounds the irregular dome of primary rocks, which form the northern highlands of New York, overlying the sandstone. It is better represented at Chazy than at any other place situated upon the flanks of this dome. At Middleville, in the Mohawk valley, it contains fine limpid quartz in its cavities together with calcareous spar and globular unbituminized coal, both in the cavities and in the interior of the quartz and spar. They also contain brown spar.

The concretionary variety is found at Little Falls near the top of the cliff of this rock, where it rests in gneiss. On both sides of the St. Lawrence it follows the quartz or Potsdam sandstone, and may be traced from Kingston to Lake Huron; it disappears under the waters of Georgian bay.

On the west side of Green bay, Lake Michigan, it crops out from beneath the Trenton limestone or its equivalent, and appears in a long narrow belt running down to Jamesville on the Rock river, where the belt runs westward to Prarie du Chien, and finally it passes up both sides of the Mississippi; near to Fort Snelling, it inclines again to the right and left, the right fork going up the St. Croix, the other follows the St. Peter's southwestward to the forks, near the Marrah Saukah lake. It has been traced upon the routes of these large rivers. On the Mississippi it is denuded on both sides, exposing to view the lower sandstone. This rock accompanies the Potsdam sandstone southwest; passing through Orange county, N. Y., into New Jersey, Pennsylvania, Virginia, Tennessee, keeping company with the sandstone beneath. I have stated that the Potsdam sandstone does not flank the Blue ridge, but follows the middle or the western side of the great southwestern valley, passing west of Winchester, one mile west of Staunton and about 2 miles west of Wytheville, at the base of Brushy mountain, and the western base of Walker's mountain. The calciferous pursues the same route and following the same valley it passes into Tennessee, but I am unable to say whether it may be traced entirely across the latter state into Alabama.

§ 11. *Mineral contents of the rock.*—This rock is not regarded as rich in metals. Dr. Owen however reports localities where lead ore (galena) has been found. Thus, on the west side of the Mississippi, fifteen miles above the mouth of Turkey river, large quantities of galena were taken from openings in this rock. Numerous localities have been observed where this ore has been found in the northwest. A few seams of copper have also been discovered by the government surveyors, but nothing which promises much up to the present time. Sulphuret of iron and blende in small lumps occur in the rock in New York, but it is unknown as a metalliferous rock; in the southwest it is equally barren.

Its Palæozoà.—This rock is rich in fossils, and contains many at certain localities. At Chazy, particularly, most of the strata are rich in organic remains. Marine plants, corals, brachiopods, gasteropods and crustaceans are abundant in this mass at Chazy. No less than three beds of lingulas, neither of which is less than ten feet thick, occur in this ancient formation. Silurian forms and types had already become numerous, and though it can not be said that the species were numerous, yet individuals of species were remarkably so. Strata are frequently made up of organic remains, among which we find only a few species; the

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simple plaited orthidæ are the most common in the fossiliferous beds.

§ 12. *Chazy limestone.*—In New York where this rock is clearly developed, it is a dark colored, irregular, thick-bedded limestone. At Chazy it is a rough, cherty mass; the fossils are imbedded in a flinty matrix. At Essex, on Lake Champlain, this rock is a thick bedded limestone, and contains less foreign earthy matter than the rock just described. This rock is not the one known as the Black river limestone, though it has been referred to as such; it is a distinct rock, one which the writer was the first to recognize by its peculiar fossils as well as by its position. In southwestern Virginia and in Tennessee it occupies the same position and contains the same fossils as at Chazy and Essex. Its thickness is 130 feet. The most prominent fossil is the Straparollus (Maclurea magna) of Le Suęur, *pl.* 4, *fig.* 15. It seems to be absent in Wisconsin and Iowa.

§ 13. *Birdseye limestone.*—This limestone is close grained and frequently compact like flint; it is brittle, and breaks with a conchoidal fracture. It is black, dove-colored, taking sometimes a yellowish tinge. The rock always has a compact structure, in which it is unlike the other limestones of the group.

§ 14. *Distribution.*—It accompanies the lower Silurian limestones in northern New York and Canada. It exists in the Champlain and Mohawk and Black river valleys. In the Mohawk valley, at a few places, it is only one or two feet thick. In Canada, it is a beautiful, light colored, compact rock, sufficiently light colored and fine grained to be employed for lithographic purposes. It is associated in the southwest with the preceding rocks. Its fossils are not numerous; the most common one is the Fucoides demissus of Conrad, *pl.* 4, *fig.* 12, 13.

Isle La Mott marble.—Is a thin, black, fine grained rock; it is a pure limestone, free from foreign matter. It will receive a fine polish, and in consequence of its fine grain and color, is highly esteemed as a marble. At Isle La Mott it is thicker than at Watertown, but its greatest thickness does not exceed twelve or fourteen feet. It merits a passing notice on account of its value as a marble. It contains a few obscure and rather broken fossils, which injure it for marble, as they make white spots. It is unknown in the north or southwest. Its fossils are similar to the Birdseye, or those below it, rather than those of the Trenton limestone which succeeds it.

§ 15. *Trenton limestone.*—This rock in northern New York and Canada is black and fine grained, or else it is a grey subcrystalline limestone. It is massive, or in thick beds, as at Trenton; in other places it is rather thin bedded and alternates with black slate as at Chazy. The upper part is shaly, and passes into the Utica slate. It is therefore not uniform in its composition and in the formation of its constituent strata. This limestone is often bituminous. In the quarries of Montreal its surfaces are adhesive from bitumen. This rock is impure, from the presence of shale or agillaceous matter, while the calciferous sandstone is impure from the presence of silex. This rock is white in southwestern Virginia.

§ 16. *Distribution.*—It is the most persistent of all the lower Silurian rocks except the calciferous sandstone. It is prevalent in northern New York and Canada, the valleys of the St. Lawrence, Champlain and Mohawk. In the northwest, in Wisconsin and Iowa, it is described by Dr. Owen as the shell limestone, but seems to be less important than the calciferous sandstone. It is also present in Pennsylvania, Virginia and Tennessee. In southwestern Virginia it is a white crystalline rock, though loaded with organic remains. Its average thickness is about 400 feet.

§ 17. *Its Palæozoa.*—Is its highest claim to notoriety. We have no rock so rich in fossils as the Trenton limestone. It contains gasteropods, brachiopods, lamellibranchiates, crinoids, and five or six species of crustacea as the Isotelus gigas, Calymene senaria, &c.

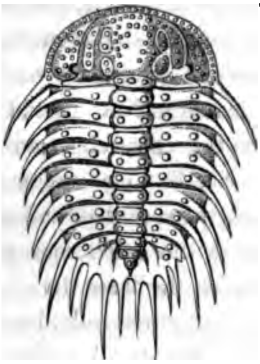
§ 18. *Utica slate.*—The Trenton limestone passes into this rock by becoming *more slaty or shaly* and losing its calcareous beds.

It is itself a calcareous shale, more or less bituminous. In New York the dividing lines between the limestones below and the Loraine shales above, are not distinct. In the western states it is merged in the blue limestone. In the southwest it is not recognizable. The calcareous shales in the gorges of Loraine, Jefferson county, in which there are neither limestone nor sandstone beds, are about seventy-five feet thick.

§ 19. *Loraine shales terminating in a thick bedded gray sandstone.*—The rock succeeding the Utica slate passes from the latter into the former by its beds of sandy shale and thin bedded sandstone. The argillaceous matter loses its lime also, and in passing upwards changes affecting its palæontology are very soon perceived. These shales consist, in the inferior parts at least, of thin alternating beds of gray sandstone and slate; the sandstone becoming thicker at the superior part, the shale diminishing, the rock finally passes into a gray even bedded sandstone. The typical rock is displayed in the gorges of Loraine and Rodman, and not upon the Hudson river. In the latter region the rock is crushed, and is by no means in a condition suitable to give character to a group, hence it should be referred to only as a modified condition of the Loraine shales.

§ 20. *Distribution of the Loraine shales and sandstones.*—In Jefferson and Oneida counties, in New York, St. John's and its neighborhood Canada East, are the most important points at the north where this group is developed.

On the Mohawk, at Cohoes, the shales and sandstones in a crushed condition, are tolerably well exposed. They may be traced to Schenectady and Saratoga, where they lie in a horizontal position. At the west near Cincinnati, this group is calcareous throughout, and is called the blue limestone. In Virginia, in Wythe county, the group consists, first, of a mottled sandstone, pebbly at the bottom and becoming marly at the top, and contains fossiliferous bands which identify it in part with the Loraine shales. Above this reddish mottled sandstone were found beds of calcareous shales and thin bedded limestone, and above, still, olive green sandstones and marls, with Pterinea carinata of Conrad. This group, therefore, differs physically here from the western group near Cincinnati, and the same group in New York and Canada. The fossils, however, are the same, with the exception that among those which occur west and north, there are a few species confined to the south. The palæontology is, however, almost identical. The rock, equivalent to the Oneida conglomerate is not universal at the south, neither are the upper beds so constantly thick bedded as in Jefferson and Oneida counties.



THE PALÆOZOA OF THE LOWER SILURIAN SYSTEM.

§21. The lower Silurian rocks of this country form one palæozoic group. The distribution of the palæozoa is such that no subdivision between any of the members would secure on either side a good natural history group. We have, it is true, been in the habit of speaking of the calciferous and Hudson river groups, but the use of the term has arisen from a restriction of a few species of fossils to those beds, which, when coupled with certain lithological peculiarities of the rocks themselves, led to this mode of grouping. If a general subdivision was necessary, the lower Silurian might be grouped under three heads, as has been virtually proposed by Prof. Rodgers; thus the Potsdam sandstone forms the first mass designated No. 1, the limestones by No. 2, and the upper rocks consisting of shales and sandstones equivalent to the Loraine shales and sandstones of New York, by No. 3. This division is applicable to New York, Pennsylvania and Virginia, but in the west the calcareous matter is continued into the upper group or No. 3. The second and third divisions, therefore, are not clearly separated, and as the Potsdam sandstone often passes into the calciferous sandstone, we find the distinctive lines between the three divisions nearly obliterated. The lower Silurian is one group only, because the palæozoa are restricted to its limits. This fact I pointed out many years ago, and was led to designate it the Champlain group, and subsequent researches have served to confirm this view. The discovery of a few dilapidated and imperfect specimens of fossils belonging to this division in the upper part of the Medina sandstone, does not affect the generalization. The occurrence of the Exogyra costata in the Miocene of North Carolina does not prove that it lived in the Miocene period, so neither does the discovery of a few weathered Champlain fossils in the Medina sandstone prove that they lived in that period.

The order which I propose to follow in describing the fossils of the group will accord with the modern systematic arrangements which have been generally adopted by zoologists. The student will find many advantages resulting from a classification which embraces both the living and extinct species, as he will thereby aid his conceptions of the latter by means of the former.

MOLUSCA.

§22. As the name indicates, are animals whose bodies are soft or a peculiar fleshy substance, as in the well known animals the clam, oyster and snail. They have no hard or bony skeleton, but are usually provided with external hard parts called the shell, which is a secretion from the skin, consisting mostly of carbonate of lime. Their nervous system is distinct, but contains but a small amount of medullary matter. They have also a circulation and all the organs of sense. The place assigned them in the rank of beings is between the articulata, as the spiders, crabs, &c., and the radiata, or the corals. This subkingdom is divided into five classes: CEPHALOPODA, GASTEROPODA, ACEPHALA, TUNICATA and BRYOZOA. These classes are subdivided into two sections; the first embraces the more perfect Molusca, all of which have a nervous gangliated cord surrounding the œsophagus; they have also the sexual organs of the higher animals, and are never aggregated or produced in family groups. The lower division, on the contrary, and which is called *moluscoides*, has only a rudimentary nervous system, no distinct ganglia, and are reproduced by buds as well as from eggs, and they are also small and live in families in a mode similar to the corals, to which they have a strong resemblance. They embrace the two last classes mentioned in the foregoing classification.

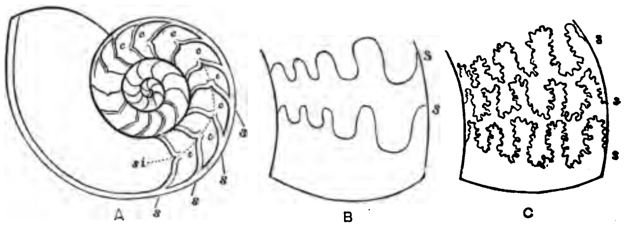
1. Cephalopoda.

Animals, some of which are destitute of an external or an internal shell, others are provided with an internal shell only, and others still with an external chambered one; head distinct and provided with eyes; instruments of locomotion and prehension numerous, and arranged about the head, and which are armed with suckers or hooks. The cuttle fish, nautilus and spirula are examples of Molusca belonging to this order. All the known living species, together with many extinct ones, were provided with a dark colored secretion stored up in a sack, the contents of which can be emitted at will, which discolors the water and thereby favors their escape when pursued by their foes. The external shell may have one or more chambers; the former are called *monothalamacea;* the latter, *polythalamacea.* The transverse partitions of the chambers are called *septa,* and the septa are perforated by a tube called a *siphon* or *siphuncle,* which may be continuous or interrupted.

Those of the class which are provided with external shells may be divided as follows: 1. Those whose shells are rolled up so as to form a circular disk; 2. Those whose shells are merely curved, or arcuate; 3. Those whose shells are straight.

Before I proceed to describe the fossils belonging to the foregoing divisions, it will be useful to the student to illustrate by figures the forms of the septa and position of the siphon, as both furnish important distinctive characters. Thus, septa are

Fig. 26.



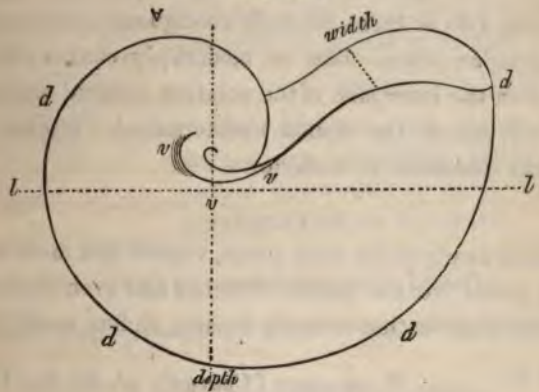
simple as in the Nautilus, fig. 26, A, undulated as in certain kinds of Ammonites, as in B, arboresecent as in C, and angulated as in the Goniatites, fig. 27, A, B.

The siphon is central as in fig. 26, A, or in other genera it is subcentral, ventral or dorsal.

Fig. 27.

The measurement of symmetrical conical univalves is shown in fig. 28. The width is measured across the aperture, the length in the direction of *l l*, and *d d*. The figure explains sufficiently the other measurements.

Fig. 28.



POLYTHALAMACEA.

Synopsis of the order.

I. Shell *discoidal*. Lituites. Trocholites Hortholus.

II. Shell arcuate; Cyrtoceras, Oncoceras.

III. Shell straight; Orthoceras, Gonioceras Actinoceras Gomphoceras Endoceras, Cameroceras, Melia.

D. *Discoidal, septa simple.*

Genus, LITUITES.

Shell discoidal; volutions contiguous; siphon central.

L. UNDATUS, *pl.* 5, *fig.* 14, 14, *a.*

Inachus undatus (*Conrad*).

Shell rolled up with its convolutions equally depressed on either side; the outside as well as the inside of the volution flattened; surface marked by strong oblique ridges between which it is finely striated; striæ upon the back form an imperfect arch. It occurs in the Black river limestone.

HORTHOLUS (*Montfort*).

Convolutions disjointed or somewhat distant in the young shell, and become more so after two or three volutions, becoming in the end nearly straight towards the aperture.

H. AMERICANUS.

Lituites convolvam (*Hall*).

Volutions, two or three, scarcely contiguous; surface smooth, section circular, septa plane or moderately convex; direction oblique from the inner side of the volution outward and upward (*Hall*); position of the siphon undetermined. Occurs in the Black river limestone at Watertown.

TROCHOLITES.

Volutions nearly in the same plane, ventral disk more concave than the dorsal; ventral surface flattened and even slightly concave; transverse section obtusely lunate; siphon small, ventral.

Fig. 29.

T. AMMONIUS (*Conrad*), *pl.* 12, *fig.* 14 *c*, 15.

Volutions about four; enlargement gradual; surface ornamented by oblique ridges, which form a distinct arch upon the back, and marked by fine waving interrupted striæ, and very obsucre longitudinal ridge; aperture suddenly enlarged as in fig. 29

Trenton limestone and Utica slate

T. PLANOBIFORMIS (*Conrad*).

The shell is rather larger than in the preceding section; more elliptical; mouth lunate; transverse ridges form a curve rather than a distinct arch; surface longitudinally striated. Loraine shales.

B. *Shell arcuate, septa simple.*

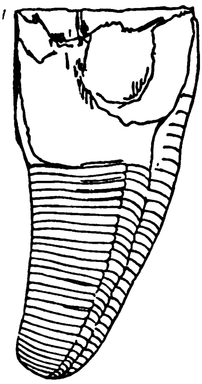
CYRTOCERAS (*Gold*).

Shell moderately curved; section circular; siphon dorsal.

C. MARGINALIS (*Conrad*).

C. Macrostomum, *fig.* 30 (*Hall*).

Fig. 30.



Shell moderately curved, enlarging rapidly towards its aperture: septa numerous; it has twelve to thirteen septa in an inch towards its small extremity. Belongs to the Trenton limestone.

C. ANNULATUS (*Hall*).

It has a central siphon, and hence should probably be placed in another genus.

C. LAMELLOSUM (*Hall*).

Shell gently curved; surface ornamented with sharp undulating lines, which are arched downwards towards the apcol extremity. Trenton limestone.

C. CONSTRICTOSTRIATUM (*Hall*).

Shell nearly straight; surface ornamented by fine transverse striæ.

C. MULTICAMERATUM (*Hall*).

Septa close and numerous, and curved at the apex; septa about thirty in an inch.

C. ARCUATUM (*Hall*).

Shell gently curved, and tapering slowly towards the apex; septa about twelve or thirteen in an inch.

C. CAMURUM (*Hall*).

Curve greater than in the preceding species; septa about nine to the inch. The three last are not marked by striæ. They all belong to the Trenton period.

ONCOCERAS (*Hall*).

Shell arcuate, swollen near the middle, siphon small dorsal; septa nearly flat.

O. CONSTRICTUM, *pl.* 12, *fig.* 2.

Shell short; constricted near the mouth, and rapidly contracting towards the smaller extremity. It is always imperfect at the smaller extremity, being apparently truncated. Trenton limestone.

C. *Shell straight.*

ORTHOCERATA.

Synopsis of the straight Cephalopoda.

I. Shell regularly tapering; siphon small, central or subcentral; section circular. Orthoceras.

II. Shell subconical, siphon ventral; section circular; siphon with interseptal swellings. Actinoceras.

III. Shell subfusiform; siphon eccentric. Gomphoceras.

IV. More than one subconical body enclosed in the shell; siphon large, ventral. Endoceras.

V. Siphon large, lateral and spiral; section elliptical. Cameroceras.

VI. Siphon large; septa waving; section an elongated ellipse. Gonioceras.

VII. Siphon large, ventral, and without interseptal swellings; section subcircular. Melia.

I. ORTHOCERAS.

Shell straight; tapering; having its siphon central or subcentral; section circular.

O. PRIMIGENIUS (*Hall.*)

Shell gently tapering; septa thin and numerous; proximate, *calciferous* sandstone.

O. LAQUEATUM (*Hall*).

Shell tapering slightly, and longitudinally fluted. Calciferous sandstone.

O. RECTIANNULATUS (*Hall*).

Shell tapering very gradually, and marked by transverse ridges. Chazy limestone.

O. SUBARCUATUS (*Hall*).

Septa rather distant; slightly curved. Chazy limestone.

O. BILINEATUS.

Tapering very gradually; low or rather flat; septa rather distant; surface marked by coarse distant longitudinal striæ. Calciferous sandstone, Greenbush. [See Palæontology, N. Y., by James Hall, p. 35. "Trenton limestone thrust up through the Hudson river slates." ! !

The fact in regard to the rock at Greenbush is, that the calciferous sandstone forms the greater portion of the calcareous mass. The upper part is the Trenton limestone consisting of thin beds of black limestone interlaminated with shale or slate, as at many localities in the Mohawk and Champlain valleys. In these beds of limestone we obtain the fossils of the Trenton limestone. Besides, it is quite difficult to conceive how one rock can be thrust through another without making a hole in it. If the specimen on pl. 7, fig. 4, is compared with those of pl. 43, fig. 14 and 15 it will not fail to strike any one that either the figures are very badly drawn, or else the fossils are quite different. To admit the existence of the calciferous sandstone below the Trenton at this place, would be equivalent to the admission of the Taconic system.

O. TERETIFORME (*Hall*).

Shell marked by subspiral rounded close annulations: surface longitudinally striated; septa quite convex; siphuncle small. Trenton limestone.

O. ARCUOLIRATUM (*Hall*), *pl.* 12, *fig.* 4.

Shell *slender; ornamented* with transversely spiral and slightly elevated undulating ridges; separated by spaces equal to their breadth; surface finely striated longitudinally.

O. TEXTILE (*Hall*).

Shell rather small slightly tapering evenly and finely striated longitudinally; undulations circular; proximate.

O. CLATHRATUM (*Hall*).

Small transverse ridges angular and finely striated and distant one half the diameter of the shell. Trenton limestone. Rare.

O. ANELLUS (*Conrad*).

Shell elongated; tapering very gradually; annulations angular; approximate and in width equaling one fourth the distance of the shell, which is marked by fine undulating longitudinal striæ. Trenton limestone. Greenbush.

O. UNDULOSTRIATUS (*Hall*).

Annulations subangular; arched upon the back and direct upon the ventral side; back transversely striated; septa quite convex.

O. AMPLICAMERATUS (*Hall*).

Shall rather large, long and tapering very gradually; siphuncle eccentric; septa distant and very convex.

O MULTICAMERATUS (*Hall*), *pl.* 4, *fig.* 8.

Elongated terete, slender, smooth; septa numerous, and distant from each other from one fourth to one half the diameter of the tube; siphon central. Birdseye limestone.

O. STRIGATUS (*Hall*).

Shell terete; surface marked by distinct and rather undulating longitudinal striæ; septa quite convex, and distant about one fourth the diameter of the shell.

II. ACTINOCERAS (*Bronn*).

Ormoceras (*Hall*).

Shell straight; subconical; siphon eccentric and swollen, or extended beyond the perforation by which it appears to be large.

A. TENUIFILUM (*Hall.*)

Shell gradually tapering, and the larger end marked by transverse striæ; siphon ventral; septa rather distant; moderately convex, double; the upper being deflected so as to enclose the swollen siphon. I have observed that when the outer part of the shell was weathered it shows annulations of growth or striæ. Distance between the septa about one-fourth the diameter of the shell. Common in Jefferson county, N. Y., in the Black river limestone, to which it seems to be confined. Williams's College Museum.

O. GRACILE.

It is less conical, or more cylindrical, than the foregoing.

O. CREBRISEPTUM.

This shell tapers gradually; the distance between the septa half as great as in the tenuifilum.

III. GOMPHOCERAS.

Shell very large; straight; subfusiform.

G. HALLII (*d'Orb.*).

Shell enlarged near the middle; contracting towards the aperture; septa approximate and rather flat; siphon large; eccentric. Black river limestone.

IV. ENDOCERAS (*Hall*).

Shell straight; siphon subcentral and large and contains two or more subconical bodies in the same tube.

E. PROTEIFORME, *pl.* 13 *and* 16, *fig.* 1 *a*, 3 *a*.

Shell circular and very gradually tapering; surfaces marked with transverse and longitudinal fine striæ; septa rather distant; inner shells subconical; finely striated; the striæ often preserved upon casts; siphuncle large and subcentral. This species is common and frequently large. It is found in the Trenton limestone at Middleville and numerous other places in northern New York and Canada.

E. SUBCENTRALE.

Shell elongated, cylindrical, and marked by distant spiral ridges; septa distant; siphuncle large; subcentral. Black river limestone. Rare.

E. LONGISSIMUM.

Cylindrical; extremely elongated and tapering very gradually. Black river limestone.

E. MULTITUBULATUM.

Contains many concentric tubes one within the other; tubes thin, smooth. Black river limestone, Watertown.

E. GEMELLIPARUM.

Large; tapering rather rapidly; septa moderately convex distant.

E. ANNULATUS (*Hall*).

Shell large tapering very gradually; annulations wide flattened; distant one-fifth the diameter of the tube; septa quite convex; siphon large.

E. *Arctiventrum*, *angusticameratum*, *magniventrum*, *approximatum*, *duplicatum* and *distans* (*Hall*).

V. CAMEROCERAS (*Conrad*).

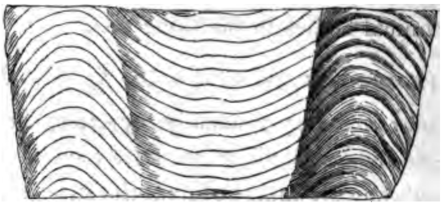
C. TRENTONENSE.

Elongated; section elliptical; diameters as five to seven; septa distant, and with low and oblique annulations.

VI. GONIOCERAS (*Hall*).

G. HALLII (*dOrb.*).

Fig. 31.



Compressed sides expanded; divergence of the edges 25°; sections are unequally flattened; ellipse; septa numerous, sinuous and double; siphon subcentral, with interseptal swellings Fig. 30. Birdseye.

VII. Melia.

Siphon large; ventral; shell large; section elliptical.

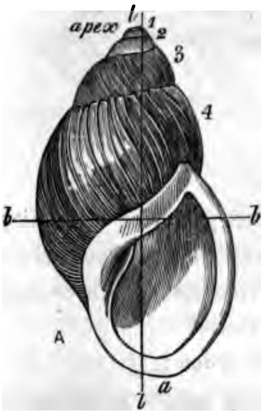
M. cancellatus (n. s).

Shells large; elongated; sides only slightly convergent; siphon large; surface marked by longitudinal and transverse striæ, giving it a pitted appearance. Loraine shales.

GASTEROPODA.

This class takes its name from the circumstance that the species it contains moves upon a large fleshy disk attached to the abdomen, which has been called a foot; the slug or snail represents this fact: In this class the head is more distinct. It is provided with tentacles which are regarded as organs of touch, and upon which the eyes are sometimes mounted. The mouth is below them, with its jaws armed with teeth. Their respiratory organs are in part fitted to perform their functions when in the atmosphere or water. The sexes are separate, or as is sometimes the case, are united in one individual. Certain species belong to fresh, others to salt water, and some are destitute of an external shell. Their shells are mostly unsymmetrical, being obliquely rolled into a spire, as fig. 32, of which *l l* is the length; *b b* the breadth; *a* the mouth, and and 1 2 3 4 the volutions forming the spire. We have an illustration in the shell of several whorls or volutions which together form a rather elevated spire.

Fig. 32.



The spire is often depressed or flattened, or does not rise above the plane upon which the spire is rolled, thus fig. 33, the Euomphalus of Sowerby (Straparollus

Montfort), is a flattened spire. Shells of this form are said to be discoid. In this case, the volutions are angular and terminate in an angular aperture, A. The depression in the middle

Fig. 33.

of the disk, is the umbilicus. These belong to the symmetrical kinds. There are still other forms of univalves which are symmetrical, where the spire is replaced by a nonspiral, subconical elevation, with a wide open aperture, upon which the animal rests. Thus in the fig.* 34, the line *a p* divides it into

Fig. 34.

two equal parts; *a*, the anterior; *p*, the posterior extremity. The muscular impression terminates at *m m*, between which there is a space left for the head or anterior parts of the animal. Shells of this form are said to be patelliform.

The class Gasteropoda embraces seven orders:

First order, the *Pulmobranchiata* — they respire in the atmo-

---

* Sowerby, Conchological Manuel.

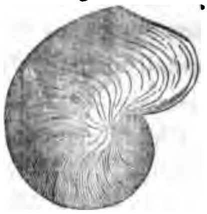
sphere; if provided with a shell, it is an oblique spiral. They inhabit the land and water, and are represented by the snail or Helices and Lymnacea.

Fig. 35.

The second order contains the *Pectibranchiata.* A part respire in the atmosphere, and a part respire in the water by means of pectinated gills. Loxonema, fig. 35, Turbo, Macrocheilus and Scalites among the fossils belong to this order. Their shells are rather thick. Of the living fresh water shells the Paludinas are examples. Several genera appear in the lower Silurian stage.

The third order composes the *Scutibranchiata.* The shells are conical, spiral or sub-spiral, and are often symmetrical; Helcion, Cyrtolites and Bellerophon are among the fossils which belong to this order; fig. 36, is the Cirtolites biloba. They appear in the lower Silurian stage.

Fig. 36.



The fourth order comprises the *Tectibranchiata.* The shell is unsymmetrical. The Bulla and Umbrella are examples of shells belonging to the order.

The sixth order contains the *Pteropoda.* The shells are thin, fragile and remarkable for their uncommon forms; the Conularia is an example. The order contains only a small number of genera. The Conularia appears in the lower Silurian.

Synopsis of the fossils belonging to the *Pectibranchiata*, which have been found in the lower Silurian:

1. Shell *discoidal.* Straparollus.
2. Shell *auriform; spire depressed.* Stomatia.
3. Shell *turbinate; volutions ventricose.* Turbo.
4. Shell *subturbinate; volutions angular.* Scalites.
5. Shell *turrited; rather elevated; aperture subquadrate; volutions rounded; surface transversely striated.* Plueratomaria.

6. Shell *turrited; middle of the volution ornamented with a spiral band; the middle of the mouth is notched.* Murchinsonia.

1. *Discoidal.*

STRAPAROLLUS (*Montfort*).

Spire much depressed; umbilicus large and grooved, and not crenulated. Aperture subquadrate.

S. MAGNUS.

Pl. 4, *fig.* 15.

Maclurites magna (*Lesuer*).

Maclurea magna (*N. Y. Geol. Rep.*).

Shell obtusely carinated on the upper edge; whorls rapidly increasing in size; aperture on the left, irregularly and horizontally depressed above; lips not deflected; surface transversely striated.—*Le Sueur.*

Chazy limestone; it is confined to that horizon, yet widely dis tributed. New York, Canada, Virginia, Tennessee, Kentucky.

S. SORDIDUS, *pl.* 3, *fig.* 6.

Maclurea sordida (*Hall*).

Spire scarcely elevated; containing about three volutions; surface smooth. It is usually about one inch in diameter. It is upon the weathered surface that they become known to us, and herein exhibit considerable diversity of form; found at Chazy in the calciferous sandstone, Bald Mountain and Hoosic Falls, and in the same rock also in Wythe county, Virginia.

S. MATUTINA.

Maclurea matutina (*Hall*).

It is usually a cast, but sometimes a distinctly striated shell, and is larger than the foregoing.

S. UNIANGULATUS (*d'Orb.*).

Enomphalus uniangulus (*Hall*).

Upper and outer edge of the volution angular; rounded below; surface striated.

S. LEVATUS *pl.* 5, *fig.* 1.

Ophileta levata (*Vanuxem*).

Volutions numerous; thin, and without an expanded mouth; angular below; surface smooth. Calciferous sandstone.

S. COMPLANATUS, *pl.* 5, *fig.* 2.

Ophileta complanata (*Vanuxem*).

Volutions numerous; uniformly thin and slender, increasing in diameter. It belongs to the calciferous sandstone.

S. LABIATUS (*Emmons*), *pl.* 4, *fig.* 2.

Outer volution rapidly widening below to a wide, angular aperture; surface smooth. Birdseye limestone, Chazy.

S. ANGULATUS (n. s.)

Shell discoid, smooth; upper surface of the outer volution nearly flat, excepting that it has a wide, shallow groove traversing it near the outer edge, forming, with the oblique inferior and outer face, a marginal ridge. Section of the outer volution, somewhat triangular.

Diameter of the disc, one inch. Upper part of the calciferous sandstone at Chazy, N. Y.

2. *Shell auriform, spire depressed.*

STOMATIA.

Suborbicular, oblong, auriform; spire drepressed; aperture wide, entire and oblique.

S. AURIFORMIS (*d'Orb.*).

Capulus auriformis (*Hall*).

Spire scarcely elevated; whorls about three, the last wide and ventricose; aperture semilunar.—*Hall.* Trenton limestone.

3. *Turbinated.*

TURBO.

T. BILIX.

Pluentomaria bilix (*Conrad*).

Volutions from four to five, larger one traversed by fourteen or fifteen spiral ridges, intersected by numerous longitudinal but oblique striæ; between the three or four first ridges there are one or two low, interrupted, parallel ones; apex acute; aperture triangular, subtransverse.

Blue limestone, Cincinnati.

T. OBLIQUUS.

Pl. 5, *fig.* 18; 18 *a;* 18 *b;* 8.

Holopea obliquus (*Hall*).

Height and breadth nearly equal; spire oblique, acute at the apex; volutions three or four, the last ventricose; aperture transverse, entire; surface smooth or finely striated.—*Hall.*

T. SYMMETRICUS (*d'Orb.*).

Holopea Symmetricus (*Hall*).

Height rather greater than the breadth; apex acute; volutions four; aperture subrotund; surface longitudinally striated by unequal lines of growth. Trenton and blue limestone.

T. VENTRICOSUS.

Pl. 6, *fig.* 19, *a*, *b*.

The volutions swollen, especially the last; heighth and breadth subequal; volutions three.

T. AMERICANUS (*d'Orb.*).

Pl. 6, *fig.* 20.

Holopea paludiniformis (*Hall*).

Spire higher than wide; volutions four, rounded, full; aperture, subangular, preserving an ovate form; casts smooth, in which condition it has been found.

4. *Shell subturbinated; volutions angular.*

SCALITES (*Conrad*).

Raphistoma (*Hall*).

Shell subturbinate; spire depressed; volutions angulated; aperture oval, with the upper and transverse margin straight.

S. ANGULATUS, *pl.* 4, *fig.* 21.

Spire low; volutions four, and angulated; aperture rather narrow, triangular, and terminating before in a rather long, curved canal. Occurs in the calciferous sandstone at Chazy, Clinton county, N. Y.

S. STRIATUS, *pl.* 4, *fig.* 30.

Raphistoma striata (*Hall*).

Discoidal; spire only slightly elevated; volutions four or five; outer margin angulated; surface coarsely and obliquely striated. Found in the calciferous sandstone, Chazy.

S. PLANISTRIA, *pl.* 4, *fig.* 16, 17.

Raphistoma planistria (*Hall*).

Subturbinate; spire formed of from three to five angular volutions; surface marked by distinct, longitudinal flat striæ, and arched in the middle part of the whorls; aperture narrow, trigonal. Calciferous sandstone.

S. STAMINEUS (*d'Orb.*).

Raphistoma staminea (*Hall*).

Spire depressed; volution externally sharply angulated, and welted upon the margin; surface marked by curved striæ above and below, separated by the sharp, welted edge.

Calciferous sandstone.

5. *Shell turrited; rather elevated; aperture subquadrate; volutions rounded; surface striated.*

Pleurotomaria.

Turbinated, spiral; aperture subquadrate, with rounded angles; outer lip with a deep slit near its union with the spire. Sowerby.

P. LENTICULARIS (*Conrad*), *pl.* 6, *fig.* 13, *a. b.*.

Shell lenticular; spire depressed; outer volution flattened above, rounded beneath, and its two surfaces forming an obtuse edge; section somewhat triangular; volutions four, gradually enlarging; umbillicus rather large; surface marked by fine striæ. This fossil is usually obtained in the condition of a cast when it is smooth; the shell is thin and not deeply marked. Common in the Trenton limestone.

P. SUBCONICA (*Hall*), *pl.* 17, *fig.* 9, 96.

Spire elevated, and terminating in an acute apex; volutions 4, 5; only slightly convex above; last carinated; the others subcarinated near the outer and lower edge; beneath, the outer volution is convex or swollen, and marked near the middle by a low ridge; surface ornamented by striæ, which are reflexed near the carina and intersected by longitudinal ones, which together form a network of lines, or a cancellated surface; aperture subquadrate; height of the spire one and a quarter inches. Trenton limestone, extending up into the Loraine shales, where it is the most common.

P. QUADRICARINATA.

This is described as having four caririna upon the last whole, and its surface marked with zigzag striæ. Birdseye limestone.

P. PERCARINATA (*Hall*).

Spire conical, subacute, ornamented with numerous spiral ridges, which are crossed by light undulating striæ; volutions three to four; umbillicus none.

P. TURGIDA.

Height and breadth subequal; volutions subangular; the last whorl inflated. Calciferous sandstone.

P. UMBILICATA, *pl.* 5, *g.* 4, *a. b.*

The shell is discoidal or very much depressed; volutions four; angular; flattened above; convex below; suture caniculated; aperture quadrangular; umbillicus large; surface marked by waving striæ. Birdseyè and Trenton limestone.

P. VARICOSA (*Hall*).

Volutions four; somewhat angular; ventricose; surface strongly striated. Birdseye limestone.

P. NODULOSA (*Hall*).

Is described by Mr. Hall as being marked by nodulose spiral ridges, or as having a short ascending spire. Birdseye limestone.

P. ANTIQUATA (*Hall*).

Large; subconical; wider than high. A cast only has been observed in the Chazy limestone.

P. ROTULOIDES, *pl.* 6, *fig.* 10.

Volutions about four; spire depressed; wide again as high; outer volution concave above; convex below; margin angular, subacute; aperture subquadrate; umbilicus small; surface striated. Resembles the P. lenticularis.

P. INDENTA (*Hall*), *pl.* 5, *fig.* 5.

Volutions three; spire acute; enlarging rapidly towards the aperture; aperture angulated or subrotund; surface finely striated. Trenton and Watertown, N. Y.

P. AMBIGUA, *pl.* 5, *fig.* 5.

Volutions about four; spire subacute; outer volution ventricose angulated; height and width nearly equal.

P. UMBILICATA (*Hall*), *pl.* 5, *fig.* 4, *a*, *b*.

Shell scarcely discoidal; spire small and low; outer volution flattened above upon the back; below it is scarcely convex; umbilicus large. The angularity of the outer volution and the large unbillicus forms its most striking peculiarities. Abundant at Watertown in the gray Trenton limestone.

6. *Shell turreted; middle of the volution ornamented with a spiral band.*

MURCHINSONIA.

They embrace those Pleurotomarias whose height exceeds their breadth, and which are ornamented with a spiral band and bent striæ.

M. VENTRICOSA (*Hall*).

Turreted; volutions about five, swollen; angulated above; surface striated; striæ bent at the angle of the volution; volutions taper rather rapidly from the larger one. Birdseye and Trenton limestones.

M. BICINCTA (*Hall*), *pl.* 5, *fig.* 6, *a*, *b*, *c*, *and* 11.

Spire rather elongate; subacute; volutions four or five; angular; last tricarinate; surface finely striated and bent at the carinæ. Trenton limestone.

M. UNIANGULATUS (*Hall*).

Spire elongated; volutions about five angular; a single spiral ridge ornaments the shell, which is also traversed by fine longitudinal lines.

M. BELLICINCTA, *pl.* 5, *fig.* 1 *and* 16 *and* 12.

Elongated, acute, formed of about five or six volutions; section of the volutions rounded convex; shell ornamented by a flat spiral band placed in the centre, and traversed longitudinally by zigzag striæ, which are angulated at the spiral band. Usually in casts and common in Trenton limestone in Jefferson county, N. Y.

M. GRACILIS.

Narrow; very much elongated; volutions six or more; apex acute; the shell is ornamented by an obtuse carina, of which no marks are left in the cast.

M. ABBREVIATA (*Hall*), *pl.* 4, *fig.* 9 *and* 13 *and pl.* 4, *fig.* 11.

The shell is marked by sharp angles, between which the surface is convex and striated. Rare in the Birdseye limestone.

7. *Spire much elongated; acute; surface covered with longitudinal threads; aperture prolonged before.*

LOXONEMA.

Spiral; turriculated; whorls convex; upper edge adpressed against the next above; without a spiral band; mouth oblong; attenuated above, effused below, and with a sigmoid edge to the right lip; no umbilicus (?); surface covered by longitudinal threads or ridges generally arched.—*Phillips.*

L. SUBFUSIFORMIS (*d'Orb.*).

Murchinsonia subfusiformis (*Hall*).

Subfusiform; spire elongated; volutions about four or five; outer lip prolonged below; the casts are all compressed. It is five or six inches high; greatest breadth of the lower whorl about one and a half inches. The peculiar longitudinal threads of the Loxonema have not been observed, as the species has been found only in casts, but the form of the lip and aperture are those of the Loxonema. Trenton limestone.

L. SUBELONGATA (*d'Orb.*), *pl.* 6, *fig.* 20

Subulites elongata (*Conrad*).

Spire high or elongated; apex acute; volutions about five; surface flat, or only slightly convex; aperture narrow; its exact form remains undetermined; it is nearly three inches long, and scarcely half an inch wide. It is distinguished by its great height and narrow and flat volutions. Trenton limestone.

L. VITTATA.

Elongated; subfusiform; subacute; volutions four or five; rather more convex than the foregoing; aperture elongated. Trenton limestone.

Analysis of the *Scutibranchiata*, belonging to the lower Silurian:

1. Shell patelliform or depressed, apex turned forward. Helcion.

2. Shell convolute subglobose or discoidal, and ornamented with a dorsal band. Bellerophon.

3. Convolutions contiguous or disjointed; dorsum without the band. Cyrtolites.

I. HELCION (*Montfort*).

Carinaropsis. Metoptoma (*Hall*).

H. subrugosa (*d'Orb.*).

Metoptoma rugosa (*Hall*).

Patelliform, mouth elliptical, sides nearly parallel, apex acute and directed forward.

H. PATELLIFORMIS (*d'Orb.*).

Pl. 6, *fig.* 1.

Carinaropsis patelliformis (*Hall*).

Patelliform, mouth wide and oval, apex acute, incurved compressed towards the back, forming rather an obtuse carina which terminates in an incurved apex.

H. ORBICULATUS (*d'Orb.*).

Carinaropsis orbiculatus (*Hall*).

Form approaching that of an orbicula, with an acute subcentral apex, finely striated concentrically.

2. *Shell convolute, subglobiform or discoidal and ornamented with a dorsal band.*

BELLEROPHON.

Shell convolute, symmetrical, and ornamented with a single or double dorsal band.

B. EXPANSUS (*d'Orb.*).

Bucania expansa (*Hall*).

Pl. 6, *fig.* 7.

Volutions about four, the last expanding rapidly into a wide everted semicircular mouth, obtusely carinated upon the back; surface of contact with the inner volution concave; section somewhat pentangular. Trenton limestone, Watertown, N. Y.

B. BIDORSATUS (*d'Orb.*).

Bucania bidorsata (*Hall*).

Pl. 6, *fig.* 8-27.

Volutions about three, outer one expanding abruptly near the wide everted aperture; dorsal carina grooved on each side of a narrow sharp ridge; surface ornamented with striæ, which are arched upon the back; aperture twice as wide as high; umbilicus deep. Trenton limestone, Middleville, Watertown, N. Y.

B. SULCATINUS (*Emmons*).

Bucania sulcatinus (*Hall*).

Pl. 4, *fig.* 4.

Sides angulated; aperture round oval; surface ornamented by undulating, longitudinal and transverse lines, the latter meet upon the back, forming with each other an obtuse angle. Chazy limestone, Clinton county, N. Y.

B. PUNCTIFRONS (*Emmons*).

Pl. 12, *fig.* 11 *and* 12.

Bucania punctifrons (*Hall*).

Shell small; volutions about three, enlarging gradually; outer, rounded or obtuse, back broadly rounded, covered with superficial lozenge shaped punctures; carinal band narrow and sharp; umbilicus deep. The direction of the obscure oblique undulations, or lines of growth, indicate the existence of a dorsal sinus, of the form of that belonging to the Cyrtolites bilobus. Trenton limestone.

B. ROTUNDATUS (*d'Orb.*).

Bucania rotundata (*Hall*).

General form rounded; outer whorl expanding towards the mouth, angular at the sides; surface transversely striated. The surface markings distinguish it from the Sulcatinus.

B. INTEXTUS.

Dorsal band narrow and sharp; surface ornamented by intersecting striæ, of which the longitudinal ones are rather strong; volutions rounded. Trenton limestone, near Watertown, Jeff. county, N. Y.

B. CANCELLATUS.

The outer whorl expanded, forming two lobes, between which there is a dorsal sinus; surface striated or cancellated by fine striæ. Loraine shales.

B. RUGOSUS (n. s.).

Fig. 37.

Volutions about three, larger angulated and the larger part covered with striæ, sharply arched upon the wide, dorsal, grooved band at the curve, both the striæ and band are discontinued and replaced by rather distant waving lines; aperture undetermined. (Rare.) Loraine shales and sandstone, Loraine, Jefferson county, N Y.

3. *Volutions contiguous or disjointed; dorsum often smooth, or only marked by ridges or a superficial sinus; no continuous dorsal band.*

II. CYRTOLITES (*Conrad*).

This genus is restricted by d'Orbiny to those shells which are destitute of a dorsal band, or have a shallow marginal sinus only.

C. BILOBATUS (*d'Orb.*).

Pl. 6, *fig.* 2.

Rotund and transversely flattened; height and breadth subequal; mouth large; bilobed, faintly striated. Trenton limestone, Loraine shales. Often transversely corrugated upon the back in old shells; but which in the Loraine shales is never marked in this way.

C. ACUTUS.

Pl. 6, *figs.* 4, 5.

The shell is compressed so as to form an acute angle upon the back; surface marked with fine striæ.

C. SUBCARINATUS (*d'Orb.*).

Pl. 6, *figs.* 25, 26.

Somewhat patelliform; compressed or subangular towards the base; apex incurved; mouth widely expanded. Trenton limestone.

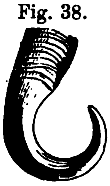
C. COMPRESSUS, *pl.* 12, *fig.* 10, *b.*

Discoidal; volutions slightly compressed and also slightly disjointed; sides rounded; back sharply carinated; surface ornamented by sharp zigzag lamellæ, which only penetrate through the shell. Trenton limestone.

C. TRENTONENSIS (*Conrad*), *pl.* 5, *fig.* 22.

Arcuate; curvature somewhat variable, sometimes it forms a short curve, in others nearly a circle, as in the annexed fig. 38:

Fig. 38.



Section triangular; aperture slightly compressed, and transversely striated, and with a shallow sinus upon the dorsal margin. The shell of this species is quite thick, and the constriction is just below the aperture.

PORCELIA ORNATA, *pl.* 17, *fig.* 2.

Cyrtolites ornata (*Conrad*).

Shell thick, consisting of two or three whorls wholly exposed and increasing rapidly in size; whorls sharply carinated; ornamented on each side with a row of twelve or fifteen ribs, which extend from the keel to the lateral angle; back crossed by elevated rows of tuberculated lines arranged nearly at right angles to the keel; aperture irregularly quadrangular.

C. FILOSUM (*Conrad*), *pl.* 12, *fig.* 4.

Shell tapering gently to a point; volution a semicircular arch; surface finely and thickly striated; striæ arched upon the back; section circular. Trenton limestone (rare).

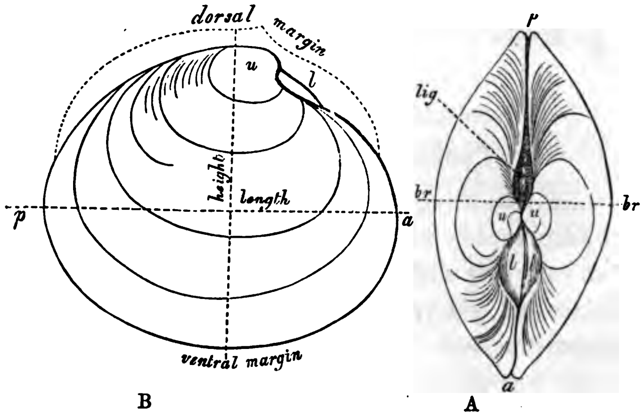
ACEPHALA.

In this class the head is wanting, it is also destitute of the organs of vision and of hearing. The mouth is unfurnished with teeth, but is supplied with fleshy lips and tentaculae which occupy the middle of the large mantle. Their shell or habitation consists of two valves. The mouth and the anal orifice being both upon the same plane but at the opposite extremities, the valve is naturally unsymmetrical, or in other words, is inequilateral; clams and oysters belong to this division of the Molusca

As a reference to the parts of the shell is constantly occurring, it will be convenient to exhibit in this place the position of certain parts of it, which are more or less employed in the description and determination of species.

This figure, from Sowerby's Conchological Manual, exhibits

Fig. 39.



B A

the parts and measurements of a common bivalve shell. The length is measured from the anterior *a* to *p*, the posterior side. The height is measured from the *umbones*, *u*, to the ventral margin. The umbones turn to the anterior part of the shell. In fig. A, *br br* is the breadth measured through the umbones; *lig.*

the ligament on the posterior side; *a p*, the length. Shells of this division of Acephala are supposed to be placed upon the ventral margin, as it is here, the foot protrudes upon which the animal moves; and hence, *a* being the anterior part of the shell, the valve on the right hand side of the observer is the *right*, and the opposite the *left* valve. The Acephala are divided into three orders. In the first the valves are right and left, and the internal impression of the mantle called the *palleal impression* has a sinus at the posterior part or region. The clam, Venus, belongs to the order.

The second division embraces those bivalves whose palleal impression is entire, and in both orders there are from two to four muscular impressions. The fresh water clam, Unio, and the mytilus belong to the second order.

The third order comprises the shells which are wholly unsymmetrical and irregular, and which lie upon the side, as the oyster. The muscular impressions upon the interior of the valves are strongly marked, and are one or two, and that of the palleal impression is entire.

LAMELLIBRANCHIATA.

1. *Palleal impression with a Sinus.*

Lyonsia (*Turton*).

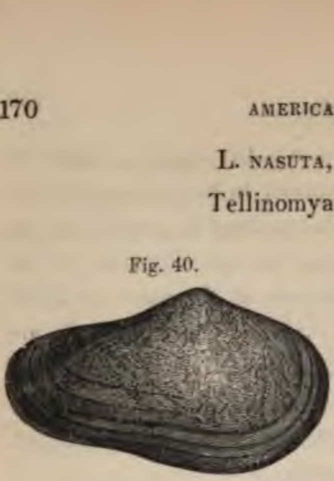
Modiolopsis and Tellinomya (*Hall*).

Shell thin, long, oval or wedgeform; palleal sinus triangular; ligament internal.

L. NASUTA, *pl.* 17, *fig.* 4.

Tellinomya nasuta (*Hall*).

Fig. 40.



Shell thin, transversely extended, inequilateral, anterior extremity rounded, narrow and more compressed than the posterior, base with a shallow sinus, umbones rather prominent and rounded, surface marked by fine concentric lines. Trenton limestone, Middleville.

L. GIBBOSA.

Pl. 14, *fig.* 3.

Tellinomya gibbosa (*Hall*).

Shell thin, transversely extended; the proportion of height to length as 2 to 3; prominent and thickened at the umbones, sinus of the base quite shallow. Trenton limestone.

L. DUBIA, *pl.* 14, *fig.* 7, 8, 12, 13.

Shell thin, small, inequilateral; extremities subequal, rounded, posterior narrow, umbones subcentral and rather thick. Common at Loraine, Watertown, Middleville, in the Trenton limestone.

L. ANATINIFORMIS.

Shell thin, inequilateral; extremities rounded, anterior narrower than the posterior; the latter subtruncate, oblique and shallow depression on each side of the umbones. Trenton limestone.

L. SANGUINOLAROIDEA, *pl.* 14, *fig.* 2.

Shell thin, transverse, rather ovate, posterior extremity much narrower than the other.

L. TRENTONENSIS.

Modiolopsis Trentonensis, *pl.* 14, *fig.* 4 (*Hall*).

Shell thin, equivalve wide posteriorly, angle line nearly straight from the umbones to one half the distance towards the posterior extremity; surface marked by fine concentric lines. The shell is rather thick and cylindrical near the anterior extremity. Trenton limestone.

L. SUBSPATULATUS.
Modiolopsis subspatulatus.

This species is distinguished by the broad expanded posterior extremity, the anterior being narrowed and truncate. Southwestern Virginia, northern New York.

L. SUBMODIOLARIS (*d'Orb.*).
Pl. 17, *fig.* 8.
Modiolopsis modiolaris (*Hall*).

Shell thin, equivalve inequilateral nearly oval, wide and expanded posteriorly, rounded and narrowed, anteriorly rounded, about twice as wide as high; surface marked by fine concentric lines of growth. Southwestern Virginia, Loraine shales.

L. SUBTRUNCATA, *pl.* 17, *fig.* 4 (*d'Orb.*).
Modiolopsis truncatus (*Hall*).

Shell trapezoidal oblique, convex breadth one-fourth greater than the height: beaks near the anterior extremity which has the muscular impression. Loraine, southwestern Virginia.

L. CURTA (*Conrad*).
Modiolopsis curta.

Shell orbicular, transverse, breadth about one-fourth greater than the length, convex and base circular; undulations of the surface distinct, but not numerous. Loraine, southwestern Virginia.

L. ANADONTOIDES, *pl.* 17, *fig.* 14.
Cypricardites Sinuata (*Emmons*).
Cypricardites anadontoides (*Conrad*).

Shell long, oval or subelliptical convex; basal line parallel or nearly so with the hinge line; sides rounded, posterior obliquely truncated, concentric striæ strongly marked. The base of many specimens are sinuate on the line beneath the beak.

L. TERMINALIS.

Modiolopsis terminalis.

This species differs from the nasutus by the position of the beaks, which are terminal, and a greater proportional length.

L. NUCULIFORMIS.

Shell small, subelliptic or subtrapezoidal, transverse extremities subacute, beaks elevated, basal margin with a shallow sinus, concentric lines numerous.

L. FABA, *pl.* 14, *fig.* 14, 15.

Modiolopsis faba (*Hall*).

Shell small, subelliptical, constricted near the beak; umbones high and rather narrow, but the posterior side expands; margin is rounded; surface marked by fine concentric lines, and a few oblique ones which run from the beak to the margin. Trenton limestone, Jefferson county, Middleville.

PERIPLOMA.

P. PLANULATA.

Pl. 17, *fig.* 17.

Cleidophorus planulatus (*Hall*).

Shell small, thin, convex, long, elliptical; extremities rounded; anterior marked by a slight groove in front of the beak, which extends half way to the base. Loraine shales, near the bottom.

LEDA (*Schumacher*).

Shell oval and prolonged into a rostrum, or becomes subrostrated, and anteriorly valves closed. Leda resembles the Nucula in its general form.

L. LEVATA (*d'Orb.*).

Pl. 14, *fig.* 10.

Nucula levata (*Hall*).

Small; the general form is oval, but in this respect it is variable; umbones wide or thick, beak incurved; subrostrated.

L. PULCHELLA.

Lyrodesma pulchella (*Conrad*).

Shell small, thin, nearly round, and rather angulated; extremities rounded; hinge line curved, and bearing about twelve or thirteen teeth; surface marked by fine concentric striæ.

L. PLANA.

Lyrodesma plana (*Conrad*).

Shell subrhomboidal, compressed; posterior basal; margin rectilinear; extremity rounded; posterior margin truncated.

ORTHONOTA (*Conrad*).

Resemble in their exterior form the Solemya. Upon the cardinal side the shells have teeth and oblique wrinkles or plaits analagous to those seen in the genus Leda. The Orthonota undulata, fig. 41, is the type of the genus, but belongs to the Devonian system.

Fig. 41.

O. PARALLELA.

Pl. 13, *fig.* 14.

Shell extremely elongated, and very narrow; anterior extremity rounded, and contracted just forward of the beaks; cardinal margin straight or gently arched; posterior extremity rounded and broader than the anterior; local margin slightly arcuate; beaks near the anterior extremity; having an obscure carina; surface marked by fine concentric striæ, and a few strong oblique wrinkles along the dorsal ridge.—*Hall*, p. 299, *Pal. Rep.*

O. PHOLADIS (*Conrad*),

Is narrow, and marked by short undulations near the dorsal margin.

O. CONTRACTA,

Is expanded posteriorly, and constricted or sinuate upon the dorsal line.

CYPRICARDIA.

C. AMERICANA, *pl.* 14, *fig.* 11 (*d'Orb.*).

Modiolopsis carinata (*Hall*).

Shell rather small, in the form of a truncate ellipse; it is traversed by a sharp ridge, which extends from the beak to the base, and by a depression which forms a sinus upon the base, giving it the appearance of being constricted; posteriorly it is truncate; surface marked by concentric lines of growth. Trenton limestone.

C. SUBTRUNCATA.

Edmondia subtruncata, *pl.* 13, *fig.* 2.

Shell broadly oval; convex; margins rounded; rather flattened on the posterior slope; a broad ridge leads from the beak to the base; casts show a few concentric undulations.

CARDIOMORPHA.

Contains those Isocardias which are without teeth upon the hinge.

C. VENTRICOSA (*d'Orb.*).

Pl. 14, *fig.* 5, 6.

Edmondia ventricosa.

Broadly ovate; umbones thick and prominent; abruptly cuneate.

C. POSTSTRIATA.

Pl. 17, *fig.* 22.

Nucula poststriata (*Hall*).

Somewhat quadrangular, and traversed by a ridge running from the beak to the base; posterior slope striated. Loraine shales.

AVICULA.

A. DEMISSA, *pl.* 13, *fig.* 10 (*Conrad*).

Shell quadrate, convex; wings extended as wide as the base; umbo rather flat; surface marked by numerous concentric lines. Characterizes the Loraine shales, and is found in south-western Virginia.

A. SUBELLIPTICA.

Avicula elliptica, *pl.* 13, *fig.* 27.

Shell subelliptical; anterior extremity compressed; umbones small; posterior wing triangular. The foregoing comprise the most important characters, as given by Mr. Hall. Being only a cast, it is indistinctly characterized. Trenton limestone.

A. INSUETA, *pl.* 17, *fig.* 15 (*Conrad*).

Shell rhomboidal, depressed; anterior wing short; posterior extended and acute; surface marked by unequal, radiating and concentric, or transverse lines. It is found in the lower part of the Loraine shales (rare).

A. CARINATA.

Pterina carinata *pl.* 17, *fig.* 23 (*Conrad*).

Ambonychia radiata (*Hall*).

Shell ovate, extended into narrow beaks, and not very convex; wing obscure; surface marked with strong radiating striæ; or rather with flat simple plaits; concentric undulations distant.

This species is widely extended, being found in northern New York, Canada, in Ohio, and southwestern Virginia. It is confined to the Loraine shales, and is the most characteristic fossil of the upper part of the Lower Silurian system.

A. TRENTONENSIS (*Conrad*).

Pl. 13, *fig.* 28, 29, 30.

Broadly oval, and wide at base; wing greatly extended; sinuous upon its lower margin; anterior wing small; surface ornamented with longitudinal lines, which are alternately light and strong, concentric lines in their intersection with them produce an elevation, giving the surface a cancellated appearance. Trenton limestone, Middleville and Watertown.

A. SUBARCUATA (*d'Orb.*).

Modiolopsis arcuatus (*Hall*).

Shell, disregarding the wing, ovate, and acute at the beak, with a proportionably wide base, which is produced in part by posterior expansion; below the wing there is a shallow sinus, as usual in this genus; surface marked by undulations; and the anterior slope has obsolete longitudinal lines. The wing of this species is very large in proportion to the body of the shell. The undulations resemble those upon the Posidonomya undata.

POSIDONOMYA (*Bronn*).

P. BELLISTRIATA.

Pl. 13, *fig.* 5, 6.

Ambonychia bellistriata (*Hall*).

Shell long, ovate; length twice as great as the breadth; convex; beaks narrow, elevated, extended, incurved; hinge line straight, oblique; surface ornamented by distinct radiating striæ. Trenton limestone.

P. ORBICULARIS (*d'Orb.*).

Pl. 13, *fig.* 18, 19, 20.

Ambonychia orbicularis (*Hall*).

Shell broadly ovate, regularly convex; expanded behind like an avicula; becomes narrow towards the beak, which is rather incurved; cardinal line straight; surface ornamented by rather waved longitudinal lines, and crossed by lighter or fainter transverse ones; near the beak the portions of the shell show dotted radiating lines. The cast is the form in which it is usually found; it is marked by wrinkles around the beak. Trenton limestone, Middleville.

P. SUBUNDATA.

Pl. 13, *fig.* 23, 25.

Ambonychia undata (*Hall*).

Shell ovate, subquadrate; acute at the beak, with a broad base; length one-fourth greater than the breadth; convex; surface marked by broad concentric undulations, and with faint longitudinal grooves; some specimens have a line extending from the beak to the base; undulations rather irregular, both in height and distance; surface of the shell smooth.

P. AMYGDALINA.

Pl. 13, *fig.* 20, 21.

Ambonychia amygdalina (*Hall*).

Shell long, oval; nearly twice as long as wide; regularly convex; base and anterior margin rounded; umbones elongated; surface of the cast smooth, and with a few obscure undulations.

P. OBTUSA (*d'Orb.*).

Ambonychia obtusa (*Hall*).

General form very much as in the preceding species; but is described by Mr. Hall as shorter, straighter and more obtuse towards the beak, with scarcely any incurvation.

BRACHIOPODA OR PALLIOBRANCHIATA.

§ 23. In many respects the Brachiopoda are the most interesting of all the orders which belong to the subkingdom Molusca. They are the oldest palæozoa of the globe; and being most abundantly distributed and varied in form and clothed with more beauty and elegance, they have become the most attractive objects of study with the palæontologist. They represent the marine fauna of the earliest periods of the earth's history, and as they still exist, connect the past with the present, having survived all the changes which the globe has undergone. Their curious structure has deeply interested the zoologist, and he has sought in the still living representatives of this ancient order, an interpretation of the curious inward organization which many of them still retain in the fossilized state. It is singular that animals so small as the Brachiopoda are, should be provided with an organization so complete, and at the same time so full as to occupy most of the space which is usually allotted to the soft, sensitive parts. We see in their calcified spiral apparatus an immense development of hard matter, disproportionate, it would seem, to the soft, sensitive substance just alluded to, in which the vital functions must reside.

§ 24. The most interesting phase, however, in which we can view them is, as palæozoa, and as representatives of the different stages through which the earth has passed; and practically for the determination and comparison of the geologic stages in different parts of the globe; for, as they are more widely distributed than most orders, they become more applicable to the purposes and objects of the palæontologist. To secure the benefits, however, which have resulted from the study of this order, it is necessary, in the first place, to become familiar with the characteristics of the families and other subdivisions which have been made by the savans of the old world.

§ 25. In this order we find a peculiarity in their attachment or mode by which they are affixed to other bodies. Most of them, for example, are provided with a fleshy process or peduncle, which proceeds from their internal hard parts, and which is attached to other bodies for support, as represented in the annexed fig. 42. It is a representation of the Terebratula, and in other genera, as in this, an orifice may be found, through which a similar organ proceeded for the fulfillment of a like function.

Fig. 42.

§ 26. In the internal parts, also, this order has another arrangement, which is common to the order. It is in the existence of the organs called the *arms*, which, when at rest, are coiled up compactly within its shell, but which might be unrolled and exposed at the will of the animal, as in fig. 43.

Fig. 43.

§ 27. The mouth is not furnished with teeth; hence, it was not adapted to mastication, and hence, too, their food must consist of minute particles of organic matter floating in the menstruum in which they lived or now live, and which may be brought to the oral orifice by means of the ciliary movements which the arms themselves are fitted to produce.

§ 28. The Brachiopoda preserve not only their distinctive type in the arrangement of the organization of the more vital parts, but also very clearly exists in the structure of the shells. Prof. Carpenter has shown that in this respect the minute structure of their habitations differs essentially from the Lamellibranchiata or Gasteropoda. It is so characteristic that even the smallest particle of the shell of a Brachiopoda can be distinguished by aid of the microscope from the shells of other classes. It shows that they worked on another plan, or followed another model in the construction of their dwellings. This structure can not always be made available to the palæontologist or zoologist, on account of the molecular changes which the shell has undergone.

§ 29. The composition of the shell is also different in this family from those which have been already described. There is more inorganic matter in them, for when submitted to the action of acids, and chemical tests, it is found to consist mostly of carbonate of lime. This fact goes to prove that as a class their rank is lower than the Gasteropoda, whose shells contain less inorganic matter.

§ 30. The position of the muscular system, or that concerned in the opening and closing of the valves, is worthy of a passing notice. In the oyster and pecten, there is one large subcentral muscular impression; in the clam and its allied genera, there are two, situated at the extremeties of the shell. In the Brachiopoda, with the exception of two or three genera, the muscles are arranged just within the beaks of the shell, and it is here that palæontologists find the most important characters for the determination of the genera.

As the Brachiopoda have been worked out in greater detail than any of the preceding classes, I propose to place before the American student a brief statement of most of the subdivisions as proposed by distinguished European palæontologists.*

§ 31. According to the best authority, the BRACHIOPODA are subdivided into ten families, and four subfamilies. The first embraces the TEREBRATULIDÆ. The beak of the larger valve is perforated, the smaller or dorsal valve is supplied with a loop or calcified process for the support of the oral appendages. Fig. 42 shows the perforation and mode of attachment of the family as has been stated. No member of this family is known to have lived until after the Silurian period.

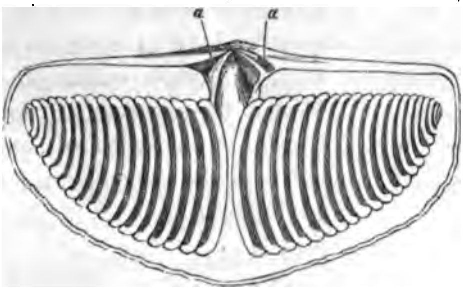
2. The subfamily STRINGOCEPHALIDAE. The labial appendages in this subfamily are supported by an extended circular calcified process or loop, from the internal margin of which numerous rays proceed toward the centre of the shell which is also provided with a mesial septum. The family is confined to the Devonian period.

* Derived from a paper published by the Palæontographical Society, by Thos. Davidson, Esq., vol. I, for 1853.

SPIRIFERIDÆ.

In this family the animal is supposed to have been free, that is, not attached by a fleshy peduncle to other bodies; the oral appendages were largely developed and were supported by

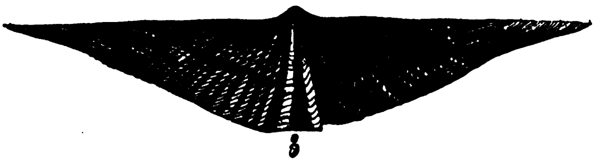
Fig. 44.



spirally rolled lamella. Its five genera which are embraced in this family are arranged in two subsections.

Genus Spirifer. Shell in its normal shape has an elongated trigonal form, inequivalve with or without a mesial fold. Fig. 45 exhibits the elongated form as it occurs in the Spirifer

Fig. 45.



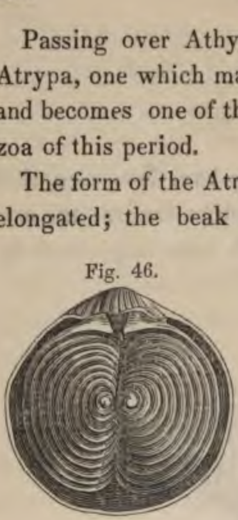
mucronatus. This Spirifer belongs to the Devonian period. These beautiful external forms are accompanied with internal arrangements and apparatus equally beautiful and more remarkable Thus, fig. 44 exhibits the spiral appendages as they are developed in the Spirifer striatus, the type of the genus.

The Spirifers make their appearance in the Trenton limestone and continue through the whole of the Palæozoic period.

Passing over Athyris and Uncites, we come to the genus Atrypa, one which makes its appearance in the lower Silurian and becomes one of the most common forms among the Palæozoa of this period.

The form of the Atrypa is circular, and may be transverse or elongated; the beak is incurved and has frequently a small round orifice, the valves are articulated by teeth and sockets; the dental valve is convex or may be nearly flat; the socket valve is convex; the mesial folds may, or may not exist. The arrangement of the spiral appendages* are the reverse of the Spirifer, being conical, but with the apex directed inward, as exhibited in fig. 46.

Fig. 46.



The outline of the Atrypa is shown in fig. 47, though it deviates in many species from this form. Thus, the A. lævis, fig. 47, is slightly elongated, it is an upper Silurian form; the A. elongata, is an extremely elongated one, fig. 48, and belongs to base of the Devonian system. In regard to the existence of spires in this and the genus Spirifer, it seems to require a favorable combination of circumstances, to preserve them, for it is extremely rare to find them remaining in the fossil.

Fig. 47.

* From Mr. Davidson's paper, published by the Palæontographical Society.

Fig. 48.

SPIRIGERA (*d'Orb.*).

The form of the Spirigera is variable; it may be circular, subquadrate, transverse and globose. It has the internal spiral apparatus and valves articulating by teeth and sockets, a short incurved beak lying contiguous to the umbo of the socket valve, or separated by a deltidium in two pieces; no true area; valves convex and divided or not by a mesial fold or sinus; surface smooth, striated or costated and marked by numerous lines of growth. There are four pits, or muscular impressions in the smaller valve and a small circular aperture close to the extremity of the umbo, the extremities of the spiral are directed to the lateral margins of the shell. In the ventral valve the dental plates extend downwards half across the shell running parallel with each other, showing within the latter elongated muscular impressions. Davidson, Spirigera concentrica, fig. 49, belongs to the Devonian system.

Fig. 49.

RHYNCHONELIDÆ.

Fig. 50.

"The animals belonging to this order were free or fixed by a muscular pedicle issuing from an aperture under the curved beak of the ventral valve. They are supplied with oral appendages which are spiraly rolled, supported by a pair of short curved processes."

Fig. 50 exhibits the general form of the genus Rhinconella.

The family at present contains only three genera. The genus Rhinconella existed in the Palæozoic seas and has come down to the present time.

Fig. 51.

The Camaromorpha, of which none have been discovered below the carboniferous system, and the Pentamerus which appeared for the first time in the lower part of the upper Silurian, fig. 51, is of an oval elongated form with both valves convex; the ventral, has an entire incurved beak, and also is more convex than the dorsal. In the young state there is a triangular fissure, but no deltidium. The dorsal valve has two distinct longitudinal septa, while the ventral has two contiguous septa coalescing into one median plate. Fig. 51, *a*, Pentamerus galeatus, shows the inside plates of the dorsal valve, and fig. *b* is a side view of the incurvation of the beak; *a* shows the septa of the larger valve.

STROPHOMENIDÆ.

§ 32. The shell in this family is convex, plano-convex, or with one valve convex and the other concave, following the curvature of the valve. The cardinal area belongs to both valves and they have a straight hinge. The family forms a large proportion of the Palæozoa of the lower Silurian system. It contains, as constituted by Mr. Davidson, four genera: *Orthis*, *Orthisina*, *Strophomena*, and *Leptæna*.

The genus *Orthis*, as now constituted, contains those fossils whose valves are usually unequally convex, but variable in shape, being subcircular or quadrate; the socket valve is sometimes flat, or even slightly concave; hinge line straight and usually shorter than the width of the shell. Both valves are furnished with an area divided by an open triangular fissure; beaks incurved, but in the ventral valve it is longest. Fig. 52

Fig. 52.

shows the most common form in the Orthis testudinaria. The internal parts of the valve furnish important characteristics also of this genus.

Fig. 53, *a b*, exhibits the teeth and muscular impressions of

Fig. 53.

the ventral and dorsal valves; *c*, the most common circular form of the valves in the Orthis quadrata.

Orthisina.

This genus has the general form of the Orthis. The cardinal area is double, hinge line straight, less than the width of the shell; fissure is concealed by a convex deltidium, which is perforated in a few species. The muscular impressions of the ventral valve are situated just within the beak in an area which is divided by a mesial ridge.

Strophomena.

This genus may be known by its flat or depressed form, its great expanse and diminutive thickness, its straight hinge line which equals the width of the shell and the conformity of the valves to each other, whether convex or concave. The cardinal area is double and crenulated at its inner edges. The fissure in the larger valve is partly covered with a convex deltidium; a small circular orifice exists in the young shell. The dental valve has two divergent teeth which are fitted to sockets in the dorsal valve. The muscular impressions are bounded by a circular ridge, open below, through which a low mesial ridge runs in the direction of the basal margin.

Fig. 54, Strophomena planumbona, shows the general form of

Fig. 54.

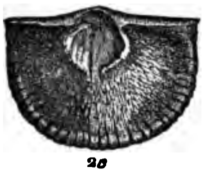
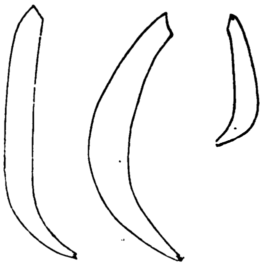
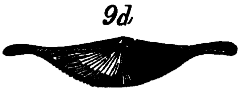


Fig. 55.



c b a

Fig. 56.

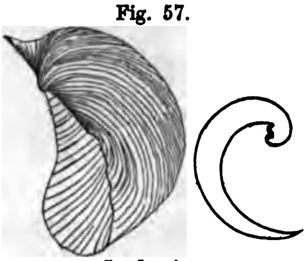


the shell and cardinal area; the semicircular ridge which limits the muscular impressions; and fig. 55, *b*, is a section of the valves showing the mode in which the margin is frequently bent. Fig. 56, *a b c*, the cardinal area.

LEPTÆNA.

Shell involute, semicircular; ventral valve regularly convex; dorsal valve concave conforming in its curvature to the other valve; area double, fissure in the ventral valve partly covered by a deltidium. In the dorsal valve the muscular impressions are large and bordered by a low ridge, and which extend to two-thirds the length of the valve, while they are small in the ventral valve, and without a margin. Fig. 57 shows the form of the shells belonging to the genus.

Fig. 57.



L. demissa.

The genera Davidsonia, Productus and Calceola are found in the Devonian system, and, as yet, being unknown in the Silurian system, will be passed over.

3. Shell unarticulated, texture horny, or calcareo-corneous, depressed, circular, and only slightly transverse; muscular peduncle, passing through a slit or foramen excavated in the lower valve.

CRANIADÆ.

The shell fixed to stones and other bodies by the substance of the ventral valve. The animal is provided with spiral arms. The upper valve is patelliform, and without articulating processes; the valves and their attached muscles being so constructed and arranged as to slide upon each other.

DISCINIDÆ.

Shell circular or oval, patelliform or conical, with the apex central or subcentral, inclining to the posterior margin; lower valve opercular, flat or subconvex, and perforated by a narrow, oval or longitudinal slit; valves unarticulated. It includes the common Orbicula of authors.

Discina.

Shell circular, oval, patelliform; the upper valve conical; the the lower, flat or convex; unarticulated; the surface is marked by lamellose lines of growth, and radiating ones proceeding from the apex. The shell structure is horny, differing in this respect from the preceding, which are calcareous.

Fig. 54.

Fig. 54 shows the form of the valves of Discina. *a* shows the lamellose structure of the upper valve, and *b*, the lower or perforated valve.

Trematis (*Shap*).

Both valves convex; the lower with a greater convexity than the upper; the umbo on the former is subcerted in the latter; submarginal fissure in the lower valve, oblong, and originating just beneath the umbo, and extending to the margin. Includes the Orbicula in part of authors.

Fig. 55.

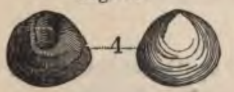


Fig. 55 shows the form of the two valves, and the aperture, *a*, in the lower valve for the transmission of the pedicle.

Lingulidæ.

Shell horny, and fixed by a muscular peduncle, as represented in fig. 56 of the recent Lingula; shell unarticulated, retained in position by muscles only. It contains two genera, Lingula and Obolus.

Fig. 56.

LINGULA.

Shell thin, equivalve, subelongate; edges parallel, or nearly so; apex acute; the peduncle passes out between the shell.

OBOLUS.

Shell circular, and orbicular, equilateral, inequivalve; slightly transverse; depressed; unarticulated; larger valve most convex, and with a short, obtuse beak, and a flattened cardinal edge, or a false deltidium produced by lines of growth, in which the groove for the transmission of pedicle is excavated.

SPIRIFERIDÆ.

ATRYPA.

Synopsis of the genus:

A. *Shell smooth, with a mesial fold or not, marked with concentric lines.*

B. *Shell plicated; plaits simple.*

C. *Shell plicated; plaits imbricated.*

A. Shell smooth, with or without a mesial fold, with or without concentric or radiating lines.

A. EXTANS (*Conrad*).

Pl. 10, *fig.* 1 *and* 11.

Shell ovate, transverse, subglobose; dorsal valve with a broad, deep sinus; ventral valve with a corresponding rounded elevation, and considerably elongated in front; beaks small, surface marked by concentric lines, longitudinal striæ less distinct. Trenton limestone, Watertown.

A. NUCLEUS, *pl.* 10, *fig.* 2.

This specie has the general form of the A. extans, but smaller, beak of the ventral valve incurved and compressed over the dorsal valve. Its characters do not clearly separate it from the A. extans.

A. BISULCATA, *pl.* 10, *fig.* 3, *a b c d e.*

Shell small, round, oval, unequally convex; dorsal valve bisculated; beak of the ventral valve incurved and close pressed upon the other; surface smooth, concentrically striated, ventral valve* with a single sulcus. Trenton limestone, Middleville.

A. CUSPIDATA.

With the mesial fold in front, the shell triangular, laterally it is subglobose.

A. EXIGUA, *pl.* 10, *fig.* 6.

Shell small, ovate valves unequally convex, beaks of the ventral valve acute, valve itself with a ridge in the middle, dorsal depressed surface marked with fine concentric lines, varying from a line to one-fourth of an inch in length.

A. CIRCULUS, *pl.* 10, *fig.* 7.

Shell small, with a suborbicular form; outline circular convexity of the valves subequal; beaks subequal; surface marked by fine concentric lines.

A. AMBIGUA, *pl.* 10, *fig.* 8, 9, 8*c.*

Form of the shell suborbicular, outline trigonal or subtromboidal, and of a medium size; beaks subequal; valves unequally convex, ventral valve regularly convex, rounded near the beak, sinus extending to the front margin; dorsal valve has a corresponding fold; surface marked by fine concentric lines, obscurely plicated; ribs plain or unimbricated.

A. HEMIPLICATA (*Hall*).

Pl. 10, *fig.* 10.

Shell wider than long or transverse, unequally convex, beaks small, ventral valve with a broad fold, plicated below and

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* I apply the term ventral valve to the one whose beak is curved over and upon the other; dorsal valve is therefore the small valve.

with lateral plications, none of which extend to the beak, mesial fold in the dorsal valve plicated, broad not deep; plications usually two; it is also laterally and coarsely plicated upon the margin; surface usually smooth. There are some variations in form, some having wide frontal margins; in others the plications are variable in extent, and in some the ridges bounding the sinus are more angulated than in others; the ventral valve is usually quite prominent, giving a gilbous form to the fossil. Trenton limestone, to which it is confined.

A. SUBTRIGONALIS, *pl.* 10, *fig.* 12.

Form of the shell trigonal, rounded in front, which is broad and from which it tapers rapidly to a small beak, convexity of the valves subequal; ventral valve regularly convex with a small triangular foramen, under a slightly incurved beak; valves with about twenty plications of which the mesial sinus has three, and the corresponding fold has four.

A. RECURVIROSTRA, *pl.* 10, *fig.* 5.

Shell small, ovoid; ventral valve regularly convex; beak incurved, sinus shallow and obscure, plications small and about twenty-four, and extending from the beak to the base.

A. PLICIFERA, *pl.* 3, *fig.* 29.

Shell somewhat trigonal, small, incurved and of a medium size; convex, but rather depressed or flattened; marginal line undulating; sinus shallow and not extending farther than the middle of the shell; plications about twenty rounded and equal, five or six belong to the sinus. Chazy limestone.

A. PLENA (*Hall*).
Pl. 3, *fig.* 28.

Shell of a medium size, rounded and convex, rather ventricose; ventral valve with the short, small beak only slightly incurved and close pressed upon the other; plications undivided and from fifteen to twenty and plane, with about four or five belonging to the sinus and opposite fold. Common and in beds of the upper part of the calciferous sandstone.

A. ALTILIS, *pl.* 3. *fig.* 30.

Shell of a medium size, rotund or convex; dorsal valve rather more convex than the ventral; beak small acute, and the ventral one incurved over the other. Plications equal, rounded and about twenty-four, eight of which belong to the mesal sinus and mesial fold; marginal line waving; occurs in the Chazy limestone and upper part of the calciferous sandstone.

A. ACUTIROSTRA.

"Shell small or minute trigonal; plications equal, and about twelve or fourteen; the central one on the ventral valve extending half way to the beak."

A. DUBIA, *pl.* 3, *fig.* 23.

Small, wide in the middle and converging rapidly to the beak; beak of the ventral valve small, incurved; plications about thirty. Chazy limestone.

A. SORDIDA, *pl.* 10, *fig.* 16.

Small circular convex, ribs undivided, rendered rugose by intersecting lines, without a mesial fold, supposed to be a young shell.

A. MODESTA (*Say*).

Shell small, circular, unequally convex; dorsal valve broadly oval, convexity much less than the ventral valve; beak of the ventral valve prominent, incurved, perforated, plications about eighteen, four of which belong to the mesial fold. Trenton limestone, extending into the shales above.

C. Ribs or plaits imbricated.

A. INCREBESCENS, *pl.* 10, *fig.* 13, *from a to x.*

Shell of the medium size, full or inflated convex, length and breadth subequal, variable in form and contour; beak of the ventral valve acute, perforated when young with a broad sinus undivided and imbricated and plaits about sixteen, with three in the sinus and four upon the mesial fold.

A. DENTATA (*Hall*).

Pl. 10, *fig.* 14.

Shell small, form somewhat triangular; outline cordiform; valves unusually convex; plications undivided, angular, strong, two of which form the mesial fold; surface crossed by numerous imbricating lines. Trenton limestone.

STROPHOMENIDÆ.

ORTHIS.

Synopsis of the genus:

A. *Ribs or plaits simple or undivided, and not imbricated.*

B. *Ribs or plaits fasciculated, or forming clusters having a common origin, and not imbricated.*

C. *Ribs or plaits imbricated.*

A. ORTHIS TRICENARIA (*Conrad*).

Shell semicircular; cardinal area high; foramen narrow; cardinal line equal to the width of the shell; apex of the central valve elevated and pointed; beak scarcely incurved; dorsal valve flat circular; cardinal angles rather rounded, inside with a mesial ridge, extending from the socket to the opposite margin; plaits numerous, variable, and undivided, from twenty-five to thirty; the points of the ribs inside have linear indentions.

O. PLICATELLA (*Hall*).

Pl. 9, *fig.* 9, *a*, *b*.

Shell rather small, transverse or broadly ovate; convexity of the valves subequal; plications merely simple, or about twenty-four in each valve, number variable. Trenton limestone.

O. PECTINELLA (*Conrad*).

Pl. 9, *fig.* 10, 11, *a*, *b*.

Rather large, circular, sometimes transverse, obliquely convex; cardinal line rather less than the width of the shell, and largest upon the less convex valve; plications equal, about twenty-eight, and mostly simple, a few do not extend to the beak; a few elevated concentric lines sometimes exist near the margin. It appears to be confined to the Trenton limestone.

B. *Ribs or plaits divided, sometimes fasciculaled.*

ORTHIS TESTUDINARIA (*Dalman*).

Pl. 9, *fig.* 1, *a* to *i.*

Circular, rather transverse, planoconvex; cardinal line straight, less than the width of the shell; angles rounded; cardinal area rather small; beak of the ventral valve prominent, slightly incurved; foramen rather wide; plaits numerous, in fascicles of about six in each, but not constant; middle of the ventral valve prominent upon the umbo, against which there is a corresponding shallow sinus in the opposite valve; inside of the dorsal valve there is a mesial ridge, which disappears about the middle of the valve, or becomes less prominent. The O. testudinaria is the most common Orthis of the Trenton limestone; it extends into the Loraine shales, where it is less abundant.

O. SUBÆQUATA (*Conrad*).

Pl. 9, *fig.* 2.

Differs from the O. testudinaria in the nearly equal convexity of the valves.

O. DISPARILIS (*Conrad*).

Pl. 9, *fig.* 4, *a*, *c*, *b*.

Small, semicircular, concave or planoconvex; area prominent, or the beak of the ventral valve elevated; foramen narrow; plaits about twenty-eight, one-half commencing upon the umbo, traversed by numerous concentric lines. Trenton limestone.

O. PERVERTA (*Conrad*).

Small, circular; convexity of the valves unequal; area of the valves nearly equal; surface marked by numerous radiating lines, which divide upon the umbo.

O. fissicosta (*Hall*).

Pl. 9, *fig.* 7, *a*, *b*.

Circular and transverse; cardinal line less than the width of the shell; beaks incurved; valves unequally convex; plaits about twenty; angular and divided twice or three times near the middle.

O. insculpta, *pl.* 9, *fig.* 12.

This fossil is described by Mr. Hall as resupinate; dorsal valve depressed, convex; beak elevated, not incurved; cardinal line less than the width of the shell; area short; surface marked by fine elevated radii; bifid upon the umbo, and again bifid or trifid towards the margin of the shell; and transversely marked by strong concentric lines. The interior vascular impressions of the valves renders it quite doubtful whether this is an Orthis; the muscular impressions, and those of the vessels are quite different from an Orthis.

O. dichotoma (*Hall*).

Pl. 9, *fig.* 13.

Convexity of the valves unequal; plications bifurcate midway between the beak and the base; crenulations indistinct. Blue limestone of Ohio.

O. subquadrata (*Hall*).

Form of the shell subquadrate; valves unequally convex; cardinal line much shorter than the width of the shell; angles rounded; foramen small; ventral valve flattened near the margin; plications numerous, sharp, crossed by numerous concentric lines, which give the appearance of having an imbricated structure, yet, when worn, these lines are obliterated. Blue limestone of Ohio, and unknown in New York.

O. occidentalis (*Hall*).

Shell transverse, or wider than high; beak unequally convex; hinge line shorter than the width of the shell; beak of the ventral valve large, incurved, with an elevation extending from the middle of the valve to the margin; mesial sinus wide and shallow in the dorsal valve; surface marked by numerous, sharp, bifurcating radii. Blue limestone of the West.

O. SINUATA (*Hall*).

Rather large; wider than high, semicircular; umbo rounded, prominent; beak incurved; area narrow; valves unequally convex, ventral, with a broad rounded elevation, to which the sinus of the dorsal valve corresponds; surface marked by numerous radiating striæ, which are somewhat crenulated.

O. SUBJUGATA (*Hall*).

The O. subjugata is described by Mr. Hall as semioval, with a point somewhat produced, dorsal area large; ventral area narrow; dorsal (ventral) having its greatest elevation just below the beak; sides somewhat depressed, often flattened with a deep broad mesial depression; ventral valve convex, gibbous; surface marked by even rounded striæ, which are dichotomous and trichotomous toward the margin. Blue limestone of Ohio and the western states.

O. ÆQUIVALVIS.

Pl. 9, *fig.* 6. *a, b, c.*

Shell symmetrical; valve subequal; hinge line less than the breadth of the shell; plications above thirty, bifurcating once or twice. Trenton limestone.

C. Ribs or plaits imbricated.

ORTHIS LYNX, *pl.* 14, *fig.* 9, *a p.*

Shell thick and comparatively massive in the old shells, form variable, but usually transverse, or it may be subquadrate and globose, frequently very thick, cardinal line usually less than the width of the shell; area of the valves unequal; plaits undivided and twenty, twenty-four thick, angular and imbricated, forming with each other a crenulated margin; mesial fold has four, and the sinus three ribs, this number is variable with age.

Trenton limestone. In New York the O. lynx is much smaller than at the west in the blue limestone. It is widely distributed, being found at most, if not all the localities where the Trenton limestone occurs.

O. BELLA-RUGOSA (*Conrad*).

Pl. 9, *fig.* 3, *a b c d.*

Shell rather small, semicircular or semioval, convexity of the valves subequal, hinge line rather less than the width of the shell, dorsal valve with a narrow depression in the middle, the ventral valve has a rather elevated beak, and slightly incurved; plaits numerous, bifurcating unequally and imbricated. Trenton limestone.

STROPHOMENA.

Synopsis of the genus:

A. *Longitudinally striated.*

B. *Striated and transversely wrinkled.*

S. ALTERNATA (*Conrad*).

Pl. 11, *figs.* 1, *a b c; and fig.* 3, 5, *b c.*

Large, circular or semicircular; area very narrow, hinge line straight, sometimes the angles are bent towards the convex or ventral valve, where the angles of the valves become very thin; ventral valve perforated and bent near the middle, disc flattened or only slightly convex; dorsal valve with a convex deltidium or boss projecting into the fissure of the ventral; surface firmly striated, every third or fourth being stronger and more distinct. Cabinet of Williams College.

S. CAMERATA (*Conrad*).

Resembles the S. deltoidea, having very nearly its proportions, striæ or surface markings, but its convexity is greater than that of the deltoidea.

S. DELTOIDEA.

Shell higher than wide, somewhat deltoid, hinge line longer than the shell is wide. Ventral valve plano convex upon the disc and becoming convex below and with the middle of the marginal part produced in front, while the lateral parts are bent down. Cabinet of Williams College.

S. ALTERNISTRIATA (*Hall*).

Large, circular, somewhat wider than long; hinge line longer than the shell is wide; ventral valve with a large sub-convex disk, bent at one-fourth the distance from the basal margin to the cardinal area; striæ rather coarse, subequal.

In this species the striæ are coarser than those of the alternata and more rugose; the ventral valve has punctures between the striæ, while in the dorsal valve the surface appears to be marked by obscure transverse lines. Cabinet of Williams College.

S. FILITEXTA (*Hall*).

Pl. 11, *fig*, 9, *c*.

Shell large, circular, height and breadth subequal, hinge line prolonged beyond the margin of the shell along a projecting angle; dorsal valve, the muscular impressions strong, the saucer form area formed of a distinct layer of shelly matter which is coarsely plicated; shell punctated throughout. Cabinet of Williams College.

S. PLANUMBONA (*Hall*).

Semicircular hinge line extended beyond the margin of the shell, whole margin bent; ventral convex, dorsal valve, the fissure partly occupied by a convex deltidium; muscular impression bordered on each side by a semicircular ridge of shelly matter; which is wanting in front and permits the passage of a mesial ridge; internal margin indented with furrows alternating with ridges along the bent border; surface striated with raised lines variable in strength and in thickness. Cabinet of Williams college.

S. DEFLECTA (*Conrad*).

It is described by Mr. Hall as resupinate, semioval; dorsal valve slightly concave, elevated towards the beak, and deflected at the angles; ventral valve moderately convex, cardinal extremities deflected, cardinal area wide, and the surface has a crenulated appearance, from the crossing of the longitudinal and concentric lines.

S. RECTA (*Conrad*).

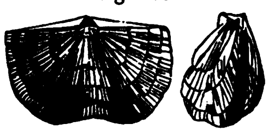
Shell small, semicircular, as wide again as high; cardinal line extended into the acute angle beyond the margin of shell; cardinal area narrow; striæ bifurcating; surface crenulated. Cabinet of Williams College.

S. SERICEA, *pl.* 11, *fig.* 6. *a b c d.*

Shell small, semicircular, depressed; hinge line longer than shell is wide; base line subparallel with the hinge line, or forms a true semicircle; fissure of the ventral often closed by the deltidium of the dorsal valve; perforation generally closed, greatest convexity immediately below the hinge line, or near the umbo; muscular impressions of the dorsal valve large, subquadrangular and divided by a mesial groove. Extends from the Trenton limestone to the Loraine shales. Most widely distributed of the Branchiopoda. Cabinet of Williams College.

S. SINUATA (n. s.).

Fig. 61.



Shell rather small, thick, stout for its size, semicircular, cardinal line equal in length and width; aperture open at the apex of the deltidium; umbro slightly elevated; ventral valve bent in the middle of the margin, producing a deep sinus and a projection or fold of the opposite valve. Concentric lines of growth strong, striæ bifurcate at different distances be-between the margins. The species is one-third larger than the S. sericea. The sinus resembles that of the S. nasuta, or the Orthis sinuata. Cincenati. It belongs to the blue limestone.

B. *Surface transversely wrinkled.*

S. TENUISTRIATA (*Sowerby*).

Semicircular, hinge line longer than the width of the shell; angles produced; ventral valve rather flat, margins bent down; transverse wrinkles numerous and narrow; longitudinal lines numerous, equal.

DISCINIDÆ.

Discina (*Lamark*).

The genus Discina, Orbicula lamellosa, is supposed by M. d'Orbiny not to have made its appearance prior to the Tertiary period.

ORBICULOIDEA (*d'Orb.*).

It is characterized by Mr. Davidson as suborbicular, patelliform, transversely or longitudinally oval; lower valve conical or concave; no pedicle disk, but a narrow, oval or circular aperture, situated in a furrow.

O. LAMELLOSA, *pl.* 8, *fig.* 10.

Orbicula lamellosa (*Hall*).

Rather small, circular; apex of the upper shell small, and situated about one-third of the breadth of the shell from the margin; squarmose concentric lines mark the surface.

O. FILOSA, *pl.* 8, *fig.* 9.

Orbicula filosa (*Hall*).

Mr. Hall hesitates in referring this shell, figured in the Palæontology of New York, pl. 30, fig. 9, to the Orbicula. I have not seen this fossil, and therefore shall merely refer to the figure.

O. TRUNCATA (n. s.).

Fig. 62.

Shell corneous, circular; apex eccentric, and marked with a shallow furrow, which extends one half the distance towards the margin: posterior margin truncate; cuticular surface marked by fine radiating lines, and rather strong concentric ones of growth. Trenton limestone, Middleville. Cabinet of Williams College.

TREMATIS (*Sharp*).

Orbicella (*d'Orb.*).

Shell depressed; valves unequally convex, greatest in the lower valve; umbo of the lower valve subcentral, of the upper, marginal; lower furnished with an oblong aperture for the transmission of the pedicle.

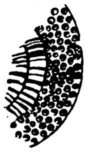
T. TERMINALIS (*Emmons*).

fig. 55.

Orbicula terminalis.

Orbicella terminalis (*d'Orb.*).

Fig. 63.



Shell circular; length and breadth of the upper valve equal or subequal; cuticle quincuntially punctate; punctures beneath the cuticle less regular and more distant than upon the cuticle, but arranged somewhat in concentric lines; shell inflected about the aperture, which opens just beneath an elevated umbo; umbo of the upper valve marked by three longitudinal lines. Fig. 63 shows the surface markings. Trenton limestone (rare). Cabinet of Williams College.

LINGULIDÆ.

LINGULA QUADRATA.

Pl. 8, *fig.* 4, *a*, *b*.

Shell large, quadrilateral; sides rounded; extremities subequal; base circular or rounded; cardinal extremity subacute; beak submarginal with a false area; marginal line circular; ventral valve rather more convex than the dorsal; surface finely marked by concentric lines, the longitudinal ones are more distinct upon the cast than upon the shell. In all my specimens there is a longitudinal groove in the middle of the shell or upon the ventral valve. The sides being thin and brittle, the margins are often broken, so as to appear parallel. Trenton limestone. Cabinet of Williams College.

L. ELONGATA (*Hall*).

Pl. 8, *fig.* 5.

Shell oval; ends subequal, cardinal one narrower than the basal; elevated in the centre; surface marked by fine concentric striæ.—*Hall, Pal. Rep.*

S. PAPILLOSA (n. s.).

fig. 64.

Fig. 64.

Umbo marginal, obtuse; surface faintly striated longitudinally; surface finely but irregularly papillose; middle marked by two smooth furrows. Trenton limestone.

L. OBTUSA, *pl.* 8, *fig.* 7.

Shell ovate; sides rounded, and curving towards an obtuse beak; beaks produced beyond the cardinal area; concentric and longitudinal lines extremely fine.

L. PRIMA (*Emmons*).

Shell small, oval, obtuse, rounded, nearly straight at the base; beak scarcely elevated above the surface of the wider part of the shell; acute; surface faintly marked with concentric lines of growth. Potsdam sandstone, Keeseville, High bridge, where it is found through a thick mass of rock for sixty or seventy feet. Cabinet of Williams College.

L. ANTIQUATA (*Emmons*).

Pl. 4, *fig.* 7.

Shell ovate, rather wide near the base, begins to taper above the middle and terminates in a rather acute beak; the shell is made up of lamellose plates, somewhat longitudinally wrinkled. Occurs at French creek, Jefferson county, N. Y., in a friable variety of Potsdam sandstone, near the top but below the Fucoidal layers.

Probably the L. prima and antiqua should constitute but one species, as both vary in form and size. The L. prima is however much smaller, upon the whole, than the antiqua. Mr.

Hall remarks that L. antiqua, figured in my Geological Report of the Second Geological District of New York, is the L. acuminata of Conrad; the figures, however, were drawn from specimens I obtained at the High bridge, and were taken from the Potsdam sandstone, and though enlarged, my shell represents the form of this species and not that of the Acuminata.

L. ACUMINATA (*Conrad*).

Pl. 4, *fig.* 9.

Shell elongated, rounded at base; sides gradually converge to an acute and subacuminated apex; umbo rather elevated, forming a ridge. Calciferous sandstone.

L. RICINIFORMIS.

Pl. 8, *fig.* 2, *a*, *b*, *c*.

This species is described as oval, convex, slightly attenuated towards an obtuse beak, with a smooth surface and obsolete concentric lines, and not exceeding one-third of an inch in length. Trenton limestone.

L. ÆQUALIS (*Hall*).

Pl. 8, *fig.* 3.

It has a very close resemblance to the L. riciniformis, but is a little larger.

L. CRASSA (*Hall*).

Pl. 8, *fig.* 8.

Shell thick, broadly ovate, subacute at the beak, and wide at the base. The unequal convexity of the valves of this species can not form a distinguishing character, as it is rather common to many others. Trenton limestone, to which it is confined.

OBOLUS.

This genus has not as yet been discovered in the Lower Silurian rocks of New York. Dr. Owen has given several figures of fossils which he refers to this genus. It appears to me that there is still some doubt respecting the identity of the fossils which have been thus referred to, inasmuch as the lower valves can not, as yet, be identified among the numerous forms which have been illustrated in Dr. Owen's valuable work.

MOLUSCOIDES.

The covering of the Tunicata not being composed of matter capable of being preserved, no animals of the class have been discovered in any formations.

BRYOZOA.

The Bryozoa resemble the polypi in their general appearance, form, distribution of the organs for conveying food to the mouth, and in being fixed to a common calcareous or corneo-calcareous support, but are still more closely related to the Molusca than to the Zoophyte. They are supplied with ciliated tentaculæ which surround the mouth, a digestive apparatus like the Molusca. They are enveloped in a mantle and protected in a cell often composed of carbonate of lime. This cell has an operculum, and contains a single individual. But these cells, though they adhere to each other and are placed upon a common axis, are never divided by septa radiating from the outer wall, and this fact will enable us to distinguish a Bryozoon from a coral, or Zoophyte. A coral has a single orifice for the reception of food and the rejection of excrementitious matter: a Bryozoon has two, and besides, the cell of a coral never has an operculum. When the septa or partitions of a coral cell are broken down, or dissolved, as they may be in a fossilized state, it is then difficult to distinguish them from each other, but we never see the cellule of a Bryozoon with septate lamina.

The number of genera belonging to the Bryozaries is not numerous, I shall however describe those only which are known in the lower Silurian system

Genus PTILODICTYA (*Lonsdale*).

The cells are either round or rhomboidal, growing upon two sides of a lamellous support and arranged in a quincunx order.

P. RAMOSA (*d'Orb.*).

Pl. 4, *fig.* 1, 1 *a.*

Stictopora ramosa (*Hall*).

Cells on both sides, of a branching calcareous support, forming a crust upon which they are arranged in parallel lines, so as to form a quincunx order; mouths oval opening obliquely upward.

P. LABYRINTHICA (*d'Orb.*).

Pl. 4, *fig*, 14, 18, 22 *and* 3.

Stictopora labyrinthica (*Hall*).

The branching stems are flattened and flexuous, branches forming an axis which bear upon both sides oval cells arranged in quincunx order. This Bryozoon is abundant on the weathered surface of the Birdseye limestone at Chazy.

P. ELEGANTULA (*d'Orb.*).

Pl. 7, *fig.* 4, *a b c d.*

Stictopora elegantula (*Hall.*)

The branching celluliferous axes are somewhat flexuose supporting oval cells arranged in close lines, upon which they alternate. Trenton limestone.

P. RECTA (*d'Orb.*).

Escaropora recta (*Hall*).

Axis cylindrical, simply tapering, the tubes with open mouths and oval, margined with or inclosed in rhomboidal spaces, and arranged in regular lines.

SUBRETEPORA (*d'Orb.*).

Intricaria (*Hall.*)

Cellules large, and arranged in single lines upon anastomosing or dichotomous branches.

S. RETICULATA, *pl.* 7, *fig.* 8, *a b.*

Intricaria reticulata (*Hall*).

Axes branching and anastomosing, sometimes regularly and forming thereby pentagonal or hexagonal meshes; mouths circular and in single rows. Trenton limestone, Bridport, Vt.

SULCOPORA (*d'Orb.*).

It differs from Ptilodictya in the cells being arranged in lines with a furrow between them.

S. FENESTRATA (*d'Orb.*).

Stictopora fenestrata (*Hall*).

Pl. 3, *fig.* 5, *a b.*

Cellules in rows separated by a furrow running in the direction of the axis of support, mouths oval or rounded. Chazy limestone.

ENALLOPORA (*d'Orb.*).

Cellules projecting upon the sides of a compressed branching axis, and never anastomosing; cellules alternating; mouths circular or nearly round.

E. PERANTIQUA (*d'Orb.*)

Gorgonia perantiqua (*Hall*).

Pl. 7, *fig.* 5. *a b.*

M. d'Orbiny refers to the Gorgonia perantiqua of Hall, the foregoing fossil. The celluliferous branches are subdivided and appear to proceed from a common central support. Bridport landing, Vt.

STELLIPORA (*Hall.*)

This genus is characterized by Mr. H. as being formed of a thick expanding crust having star shaped elevations composed of from four to nine rays, the upper edges of which present numerous elevated pores. Fig. 19, pl. 7, is referred to this genus under the name of S. anthoidea. Trenton limestone.

PTEROPODA.

CONULARIA (*Miller*).

Shell straight pyramidal; opposite sides similar and equal; angles grooved; texture delicate and somewhat like a woven fabric; apex solid, and separated from the open shell above by a simple imperforate, very convex septum.*

C. TRENTONENSIS (*Conrad*).

Pl. 16, *fig.* 4.

Shell pyramidal, four sided, equal, and separated by longitudinal furrows, angles of divergence of two opposite sides, about 28°; sides ornamented by numerous parallel ridges meeting in the middle of each face at an angle, and forming shallow grooves; spaces between the ridges concave and traversed by other sharp ridges and interrupted by the transverse ones. Trenton limestone, cabinet of Williams College.

C. GRANULATA (*Hall*).

Pl. 16, *fig.* 5.

Angle marked by linear grooves and surface by striæ, which are crossed by finer longitudinal ones, giving a granulated appearance to the shell under the microscope.—*Hall.* Trenton limestone.

C. PAPILLATA (*Hall*).

Pl. 16, *fig.* 6.

It is described by Mr. Hall as gradually diminishing towards the apex, and as marked by regular lines of granulations, the spaces between which are elevated.

C. GRACILE (*Hall*).

Pl. 16, *fig.* 7.

Slightly arcuate; surface marked by sharp undulating transverse striæ, longitudinal ones rather indistinct.

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* In the Palæontology of New York, it is stated that the Septa are perforate; this statement, however, requires confirmation. There is no perforation in a septum which is well exposed in a specimen in my collection.

C. HUDSONIA (n. s.).

Fig 65.

Pyramid elongated; sides equal or subequal; transverse furrows meet in the middle of a face at an angle of 130°. The edges of a side diverge at an an angle of about 25°. Both the transverse and longitudinal striæ are stronger than those of the C. trentonensis; there being more than twice as many in the latter as in the species under consideration. The markings have a general resemblance to the C. trentonensis, excepting that they are much coarser and the fossil is much larger. Loraine shales, Loraine, Jefferson county. Cabinet of Williams College.

CRUSTACEA.

It embraces those animals which belong to the subkingdom Articulata. The more perfect orders of this subkingdom have a true vascular circulation and a branchial respiration. Their thorax which is covered with a shield, conceals more or less the the head. The abdomen is usually composed of many joints or rings, but in this respect the number varies from five to seven pairs. There are types of Crustaceans, however, in which some of the foregoing characters are effaced.

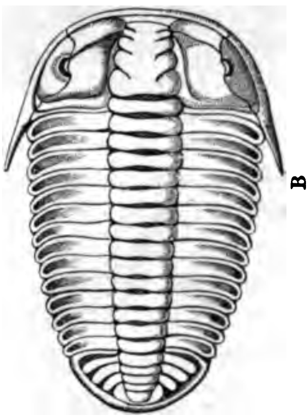
The crabs and lobsters represent this class or subkingdom.

Those crustacea, however, in which the palæontologist is most interested, are the Trilobites. This order of crustacea deviates somewhat from the true type representing the class, rather in its embryo than in its mature state. They form an order, the species of which are closely related. They are all extinct, and indeed they belong to the oldest palæozoa of the globe. None are found in the Mesozoic period. The normal type of the

Trilobite is expressed in the ordinal name which has been universely applied to them; thus the shield or integument which covers them is divided usually into three lobes by mesial furrows which traverse them longitudinally and then the anterior part the head, the middle or abdomen, and the posterior extremity are clearly indicated by marks which are easily recognized. Thus in the Conocephalus striatus, fig. 66, A marks the head; B, the abdomen, and C the tail; the latter is usually called *pygidium*. The proportional extent of the foregoing parts is variable in different genera. The form of the head is more or less expanded into a border, which is frequently ornamented by granulations, spines or perforations. Behind, the head is limited by a kind of border which is called an occipital ring. The middle part of the head, which is really one of its lobes, is called a glabella; it is not always distinct, for in the Illaenus crassicauda, pl. 18, fig. 5, the longitudinal grooves are very indistinct. The parts of the head are united by suture. The principal suture which is seen in fig 67, forms a double curved

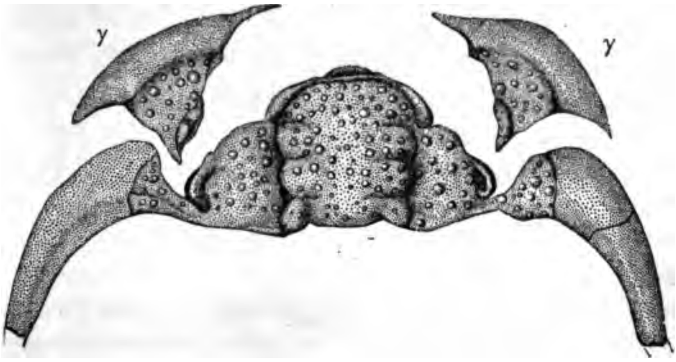
Fig. 66.

A



C

Fig. 67.



line, beginning before, near the front, it extends back to the posterior angle of the buckler, thus *y y*, cheek pieces separated from the head through the principal or great suture in the ceraurus pleurexanthemus. The eyes are apparently formed upon the type of the insects of the present day, consisting of fixed sperical lenses, which are sometimes flattened, they are large and nnmerous in the genus Phacops and in the Isotelus.

Fig. 68.

This figure is an enlarged view of the compound eye of the Phacops macrocephalus which belongs to the Devonian period, but the eye is not more perect, however, than those of the Phacops calicephalus and Isotelus gigas of the lower Silurian period. But many of the genera seem to be deprived of eyes, as the Atops and Eliptocephalus of the Taconic system, and the Triarthrus, Beckii of the lower Silurian. The number of lenses is also variable in different genera. They are placed upon the great or principal suture of the head, or near it.

The abdomen is composed of rings which are variable in number in the different genera, and, indeed, in consequence of this metamorphosis, the number is variable in certain species at different periods of their existence. In the adult state the number is constant in the same species.

The body of the trilobite being composed of separate parts arranged transversely, enables it to roll itself up on its longitudinal axis, as represented in *pl.* 18, *figs.* 6, 7, 8, 9. Certain trilobites, however, are incapable of performing this peculiar movement, and of assuming the globular or spheroidal form.

The structure of the pygidium is as variable as that of the abdomen; the number of rings is inconstant; in the oldest trilobites, or those of the palæozoic age, the organ bears generally a smaller proportion to the rest of the body than the more recent; fig. 68 and 69. This is seen in the Atops and Paradoxides, where the pygidium is reduced to the smallest number of elements, and in the Asaphus expansus, *pl.* 18, *fig.* 4, of the Upper Silurian.

Pictet, in his most valuable work, "Traité de Paléontologie," proposes the following modified classification of Barrande:

Fig. 69.

I. *Head very distinct in its conformation from the pygidium, which is very small, and the thorax large. It contains two genera, viz:* Harpes, *fig.* 66, *and* Paradoxides, *p.* 115.

The Harpes belong to the Lower Silurian. It has been found in Ireland and Bohemia, but has not as yet been discovered in this country. It is remarkable for its wide, perforated border of the cephalic shield. It is also doubtful whether the Paradoxides has as yet been discovered in our rocks.

II. *Pygidium and thorax subequal.*

It contains two families: the Calymenides, and the Lychasides. A perfect example of the latter family is known in the Lichas boltoni of the upper Silurian, and the Phacopiens, in fig. 67, Phacops limulurus.

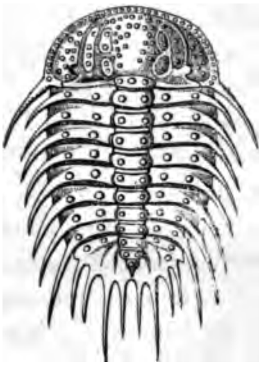
III. *Pygidium large, thorax small.*

It contains four families; the Trinuclides, *pl.* 17, *fig.* 1, the Asaphides, the Æglinides and the Illænides, *pl.* 18, *fig.* 5.

Fig. 70.

IV. The division contains three families.

Fig. 71.



1. Pygidium from two to five segments, terminating in points, as Acidapsis, fig. 71.

The second family, under this section, has the pygidium armed with points; but the segments are more numerous than in the preceding, as the Amphionides.

The third family, the Brontides, the pygidium has a very short axis, and a wide lateral extension, and marked by radiating furrows extending from the centre to the circumference.

V. *Head and pygidium very nearly of the same form, as* Agnostus, fig. 74, *d*, Beyrichia, fig. 74, *a*, *b*; p. 218.

I. *Head and pygidium distinct.*

TRINUCLIDES.

II. *Pygidium large; thorax small.*

TRINUCLEUS.

Form a short ellipse; smooth surface; head largely developed, and bordered with a perforated limb, which terminates in long spines; cephalic shield composed of three prominent convex lobes; the furrows of the glabella converging towards the axis; thorax with six rings, those of the pygidium variable.

TRINUCLEUS CONCENTRICUS.

Pl. 17, *fig.* 1.

Border with three to five rows of punctures; glabella high and projecting; maxillary spine equals the length of the thorax and pygidium; spine of the glabella short, pointed; rings of the thorax grooved, those of the pygidium soldered and terminating in a border; rings of the axis twice as many as the sides

III. *Pygidium and thorax subequal.*

CALYMENIDES.

Calymene. Triarthrus.

This family has about thirteen joints or segments in the thorax; the large suture of the well developed head terminates in the angle of the cheek.

CALYMENE.

The form of the shield is oval; the head larger than the pygidium; and the latter is about one-half as large as the thorax; the crust is granulated; the front lobe of the head projecting, the lateral lobes of the glabella are globular and separated from the middle part by deep winding furrows, which nearly isolate them, the main furrows being divergent from the the front; the eyes are reticulated, but not well developed; the thirteen segments of the thorax are angulated, and the ribs or lateral lobes are bent and rounded at the extremeties; the pygidium is convex and rounded, and its centre lobe distinct and narrower than the lateral lobes. The Calymene senaria belongs to the Lower Silurian, and the C. blumenbachii to the Upper Silurian.

C. SENARIA (*Conrad*).

Pl. 15, *fig.* 16, *and p.* 216, *fig.* 9.

Shield ovate, and uniformly granulated; lobes very convex and prominent; posterior tubercle of the glabella very large and globular; the anterior very small; ribs deeply furrowed; pygidium with seven or eight segments in the middle lobe, and five in the lateral; crust continuous around the middle lobe, and each segment is so divided by a furrow as to form a subsegment to each ring. If we count the apex of the middle lobe of the pygidium, which is really divided from the others by a shallow groove, there are eight, instead of seven segments. Trenton limestone in New York, the Blue limestone of Ohio and the equivalent rock in the southwest, Virginia and Tennessee.

TRIARTHRUS (*Green*).

Shield or crust an elongated ellipse, with the posterior extremity narrower than the anterior; crust comparatively smooth, with a single row of tubercles in the middle in the young, but often obsolete in the old; furrows of the cephalic shield parallel, straight, and in a line with those of the thorax; eyes none; axis wider than the lateral lobes; thoracic rings, fourteen; rings of the pygidium, six in the middle lobe, and five in the lateral.

T. BECKII (*Green*).

Calymene beckii (*Hall*).

Pl. 15, *fig.* 12.

Glabella nearly twice as wide as the lateral lobes, and marked by two equal, oblique, impressed lines upon the posterior half, which begin in the furrow and run obliquely downwards and inwards, nearly to its middle; cephalic ring distinct, with the extremities of the furrow parallel with the oblique impressed lines; surface rather finely sculptured, as it appears under the microscope, ribs grooved, but often appear forked and rounded; showing that the groove separates them into two parts, and that they are movable on each other. In specimens less than an inch in length there are fourteen or fifteen thoracic rings.

PHACOPS.

Form an elongated ellipse broad in front, broad or acute behind. Surface pustulose, or coarsely granulated; cephalic shield lunate from by the extension behind of the cheeks. Glabella separated from the eyes and cheeks by deep furrows convergent behind; eyes large and lunate; thoracic rings, eleven; rings of the pygidium variable, but terminating in a border.

P. CALLICEPHALUS, *pl.* 15, *fig.* 7 *a and* 7.

Form an elongated ellipse, rounded and broad in front, narrow and subacute behind; glabella, with rather deep winding furrows separating from its body a lobe directly behind the eye, which is marked by a furrow on its inner margin; front lobe large and rounded; posterior small, and somewhat in the form of a ring; rings of the lateral lobes of the thorax, grooved; rings in the axis of the pygidium, fourteen to fifteen, and nine in the lateral, terminating in a smooth border.

IV. Illenides.

Large smooth convex; head semielliptical or globose, usually wider than long, or transverse; eyes distant and lateral; rings of the thorax simple, eight or ten; pygidium very convex and trilobation rudimentary.

Illaenus crassicauda, *pl.* 18, *fig.* 5.

Semielliptic; sides parallel, and extremities very convex and rounded; anterior extremity rather larger than the posterior; eyes prominent and placed on a line of the middle of the pleuræ; thoracic rings, ten. Extends from the upper part of the calciferous sandstone to the trenton limestone.

I. trentonensis, *pl.* 15, *fig.* 13.

Form semielliptical, convex and globose; eyes distant, lateral; crust marked with imbricating striæ, similar to those of the Isotelus; ribs of the thorax linear simple or without furrows; trilobation none, or only rudimentary.

Isotelus (*DeKay*).

Form ellipsoidal; extremities subequal, smooth and finely pustular, convex; facial suture running at the inner base of the prominent eyes, and terminating within the angles of the cheeks; eyes placed on a line with the furrows of the thoracic rings; thoracic rings, eight; axes wider than the pleuræ; pygidium similar to the cephalic shield, but more obtuse; articulations soldered; margin broad.

Isotelus gigas, *pl.* 16, *fig.* 12.

Large extremities subtrilobate, more rounded behind; becomes obtuse by age; eye piece subglobose or spherical, supported on the inner margin of the cheeks; rings of the thorax strongly furrowed upon the axial border; surface of the pygidium marked with many very shallow or obsolete transverse furrows.

This trilobite is the characteristic fossil of the Trenton limestone, being widely distributed in this or its equivalent rock throughout the United States.

V. Asaphides.

Ogygia.

The large caudal shield, fig. 72, has been referred to Ogygia

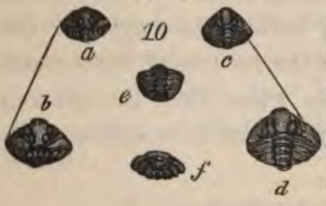
Fig. 72.

vetusta, but is more probably an Asaphus. It was found in the Birdseye limestone of the Mohawk valley; *e f g h* 9, small variety of Calymene senaria; *h*, the eye, showing the lenses; 9, the folding of the thoracic shield; *e*, the cephalic shield; *f*, pygidium.

VI. Odontopleurides.

Acidaspis trentonensis.

Fig. 73.



This species has a shield subcrescentiform, rounded and dentated in front with the cheek angles produced into spines; glabella quadrate, with a spine at the posterior margin; thorax with ten rings, and ornamented with a row of small tubercles upon the lateral lobes; pygidium with two rings and margin spinous.

ODONTOPLEURIDÆ.

Ceraurus.

Large or small; form somewhat triangular; pustulated, granulated and spinous; cephalic shield crescentiform; thoracic rings eleven; glabella quadrangular and four lobed; furrows forming the lobes extend transversely one-fourth across it; main furrows, separating it from the cheeks, nearly in a line with those on each side of the axis; eyes distant, granulated; cheeks triangular.

C. pleurexanthemus.

Pl. 15, *fig.* 1, *a to k.*

Large; cephalic shield terminating behind in long, robust, curved spines; a shallow, or wide sinus in front; thoracic rings with two rows of tubercles on the axis, and three upon the pleuræ, which are sinuously furrowed; pygidium with about four rings, and its lateral lobes armed with long, stout, curved spines, and wider than the axis; rings very prominent. Trenton limestone in Northern New York, in Ohio, and in Wythe Co., Virginia.

C. vigilans.

Pl. 15, *fig.* 2 *a to c.*

Small, subtriangular; cephalic shield granulated, crescentiform, and terminating in long, flat spines; glabella quadrangular; entire; thoracic rings eleven; axis wider than the pleuræ; pygidium triangular; axis with many rings, with every third tuberculated, terminating in a kind of spine; lateral lobes with nine ribs. Trenton limestone, Middleville; this species is quite common.

Acidaspis.

Odontopleura.

Ellipsoidal, remarkably spinous, with rows of tubercles; cephalic shield subcrescentiform, rounded in front; thorax with from eight to ten rings armed with spines; pygidium small, circular, and with few rings and spinous.

A. TRENTONENSIS.

Cephalic shield dentated in front and produced into lateral spines; glabella subquadrate; lateral furrows in a line with those of the axis; pleuræ with a row of tubercles; eyes smooth; thorax with ten rings; pygidium with two rings; margins pinous. Trenton limestone.

LYCHASIDES.

LYCHAS.

Fragments of the genus Lychas have been found in the Trenton limestone, *pl.* 15. *fig.* 2*a*; and probably an asaphus, *pl.* 15, *fig.* 11. Also the genus Thaleops, which is closely related to Illænus.

AGNOSTIDES.

Cephalic shield and pygidium nearly alike.

The agnostides are small or even minute crustaceans, having two shields very much alike; the number of thoracic rings being very small, never more than two.

BEYRICHIA SIMPLEX* (*Jones*).

Fig. 70, *a.*

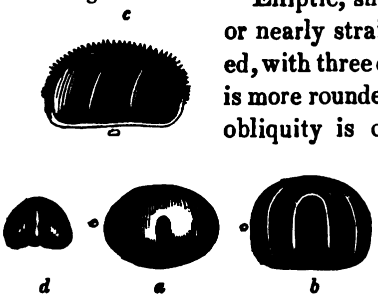
It is described as broadly ovate, globose, smooth; ventral border rounded; dorsal border somewhat angular; hinge line oblique, about two thirds the length of the valve; dorsal sulcus faintly marked on the anterior half of the valve. The description does not agree with the fossil, fig. 74, *a*; both borders are rounded, and the sulcus is variable in its depth and position. Reference is made to B. logani, Canada, and it is probable, from that reference, that it is the Canada species. Abundant in the Blue limestone of Ohio.

* Journal of the Geol. Soc. of London; vol. ix, p. 161.

B. REGULARIS (n. s.).

Fig. 74, *b.*

Fig. 74.



Elliptic, smooth; dorsal border straight, or nearly straight; ventral regularly rounded, with three distinct ribs; one of the angles is more rounded than the other, and a slight obliquity is observable in respect to the direction of the ribs. Blue limestone of Ohio.

B. CILIATA (n. s.).

Fig. 74, *c.*

Form, an elongated ellipse, smooth, with a straight dorsal border; ventral border strongly rugose, ciliate; ribs three, and oblique with respect to the straight border. The ciliæ scarcely come under that denomination, as they appear too rugose when seen under the microscope. Blue limestone of Ohio.

AGNOSTUS LOBATUS (*Hall*).

Fig. 74, *d.*

Small, trilobate; base and sides furnished with a narrow border; a small tubercle often exists near its larger extremity. —*Hall, Pal. of New York, Vol. i.*

This species, which is referred by Mr. Hall to the Hudson river group, is really confined to the Calciferous sandstone; the mass of limestone to which he refers is that rock, and contains numerous fragments of Illænus, similar to one in the same rock at Chazy; and also found in fragments in the Trenton limestone and calciferous sandstone at Greenbush.

CYPROIDES.

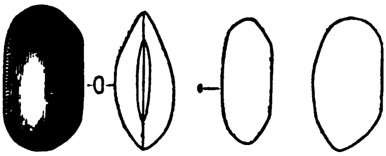
The animal is enclosed in a bivalve ovoid carapace, or of a reniform shape, supplied with a dorsal hinge, and which is completely shut, but when open allows the extrusion of its feet and antennæ. They are small crustaceans, some of which are microscopic.

CYTHERINA SUBELLIPTICA (n. s.).

Form subelliptical, smooth; dorsum nearly straight, sometimes sinuate; anterior edge with an oblique truncation extending from the hinge to the anterior edge, and forming a kind of short beak; posterior and anterior edges rounded; it is about three-fourths of an inch long. It is abundant in the upper part of the calciferous sandstone, about one mile from Watertown upon the Black river. Fig. 75, *a*.

C. CRENULATA (n. s.).

Fig. 75.



d *c* *b* *a*

Obtusely oval, smooth, inflated; hinge straight with the valves extended back, and forming, apparently, a groove; extremities rounded; anterior edge crenate. Fig. 75, *d*, *c*, hinge or dorsal side. Trenton limestone, Middleville.

C. SUBCYLINDRICA (n. s.).

It is smaller than the preceding, and of a cylindric or subquadrate form; smooth; extremities dissimilar, and without crenulations upon the edge. Fig. 75, *b*. Middleville.

DIKELOCEPHALUS (*Owen*).

This new genus is described by its discoverer as having a semicircular, rather flat, cephalic shield; a moderately convex glabella, separated from the cheeks by parallel furrows, giving it a quadrate form, and marked by two curved furrows extending from side to side, and another impressed faint one on the outer margin; facial sutures distinct, and somewhat sigmoid. The cheek pieces are produced into spines of moderate length; rings of the thorax supposed to be eight, with an axis narrower than the lateral lobes; lateral lobes wide, plain, and without grooves; pygidium with seven or eight rings in the axis, and the lateral lobes expanded widely into a flat, grooved border, with the posterior corners produced.

The large trilobite belongs to the lowest sandstones of Iowa, which are equivalent to the Potsdam sandstone.

Prof. Owen describes five species of Dikelocephalus, viz: D. minnesotensis, D. pepinensis, D. miniscaensis, D. Iowaensis, D. granulosus. They all belong to the lower sandstone, No. 1; but some pass up into the lower magnesian limestone. Dr. Owen has also discovered other forms of trilobites, some of which constitute new genera, and a new species closely allied to the Isotelus gigas, having a facial suture, eyes, extremities and ribs similar to this common form of Trenton species; the eyes, too, are placed on longitudinal furrows as in Isotelus. It differs from the Isotelus in having its cheek produced into a long spine.

RADIATA.

The kingdom contains those animals whose constituent parts are arranged about a centre in a radiate form. This radiate form is characteristic of one of the four great types upon which animals are created. Radiated animals are divided into three classes. The Echinodermata or Starfishes, the Acalepha or Jelly-fishes, and the Polypi or Corals. The Jellyfishes being composed of soft, perishable matter, are never found in a fossilized condition. In the Lower Silurian rocks the animals belonging to the other two divisions occur.

The first which I shall describe belong to the *Echinodermata*, or *Echinodermis*. The name which has been applied to this division means skin with spines. These appear under three forms. 1. the starlike form, as the starfish of our coast. 2. The Echinidæ, the egglike form, which are called sometimes sea-eggs; and 3. The Holothuridæ, which are mostly sack-like, and contain only a few, internal, semi-ossified supports, but do not occur in a fossilized state.

Only two forms of the Echinoderms are known to belong to the Lower Silurian period. One which is like the starfish, and the other which is supported upon a jointed stem, which was attached to the sea bottom. To the latter form has been applied the name *Encrinite*. The general form of the Encrinite is exhibited in the annexed wood cut of the Eucalyptocrinus decorus of the Niagara group, or Upper Silurian.

Fig. 76.

3

It is composed of a head of a globose form, supported on a stem composed of joints of which a few remain below; above, the head is encircled by arms, composed of numerous plates, which diminish in size; within this circle of arms there is an oral aperture or mouth; the head is made up of numerous plates of a hexagonal or pentagonal form, sometimes heptagonal, which are fitted together by suture, and which, on the death of the animal, may separate from each other. The plates are variable in number; at the base some begin in threes, others in fives, and are sometimes arranged in as many as nine series, varying from three to nine in the series. These are arranged in rows, encasing within the hard, dermic walls the soft parts necessary for the performance of the vital functions of this peculiar organic type. A horizontal view of the elements composing the head is shown in *pl.* 18, *fig.* 1, 2. A detailed explanation will be given hereafter.

Encrinites appear to have been among the oldest fossils of the Silurian rocks. None occur in the Potsdam sandstone, but in the lowest layers of the Calciferous sandstone, not only joints and fragments of stems occur, disseminated through the layers of the rock, but entire beds of columns occur from two to fifteen feet thick. Some of the plates are figured, *pl.* 3, *fig.* 9.

As these are fragments more or less broken and no well defined combination of plates occur, or have yet been found, it is difficult to determine the genera and species to which they belong. Some of the elements of the columns belong to the Cystidea. Some of the plates preserve the ovarian aperture, and exhibit the saucerform joints of the stem.

Of the Echinoderms, two species have been discovered by different individuals, and which have been described and figured in the Palæontology of New York. The most distinct and perfect resemble a small star-fish. It belongs to the genus *Cœlaster* of Agassiz. Two species are described the C. matutina, and the C. tenuiradiata. The five arms of the C. matutina have each three rows of plates to the pelvis. It belongs to the Trenton limestone. The latter, the C. tenuiradiatus is known by a single plate, or the madreporiform tubercle, of the back of an asterias. Pl. 3, fig. 11, is a figure of the plate.

GLYPTOCRINUS (*Hall*).

Head conical; pelvis composed of five plates, the remainder are hexagonal and six-rayed, and the entire series consists of nine rows. The peculiar sculpturing of the plates form an arrangement which will serve to identify this beautiful fossil of the Blue limestone of the west. The elements of the upper part of the column are round with fine and stellate sculpturing upon the disc, the lower and larger plates are crenulated upon their margins.

HETEROCRINUS (*Hall*).

The number of pelvic plates is five, the series is composed of this number throughout, but the rows vary from four to nine. The head is small, short, and tapers from the middle.

H. DECADACTYLUS.

The column is composed of pentagonal plates with stellate disks and a central tubercle or eminence; sides sinuous and margins of the disc sculptured with elevated stellate lines or ridges.

It occurs in the Loraine shales. The small cylindrical heads are not uncommon in the fine soft slates of this formation.

SCYPHOCRINUS (*Zenker*).

Schizocrinus (*Hall.*)

The base of the series of plates, five; the head' cup form, and the series in six rows; hand and fingers bifurcate.

S. NODOSUS.

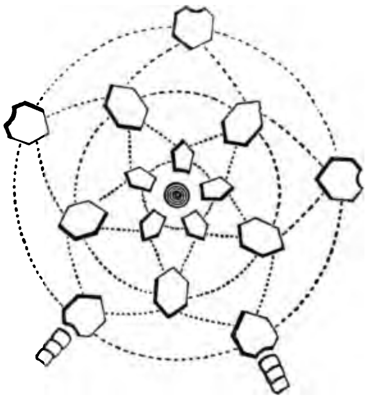
Column long, round, composed of elements of variable forms or patterns, according to their distance from the head. The most obvious character consists in the regular occurrence of projecting nodulose plates, or rather, their margins are somewhat moniliform. Their discs are finely stellated. Trenton limestone.

POTERIOCRINUS (*Miller*).

The cupform calyce is composed of a pelvis with five plates in the base of the series. There are five additional series, one composed of rather large hexagonal elements, and the last heptagonal ones which are connected with the arm plates.

P. ALTERNATUS.

Fig. 77.



The tentaculæ are fimbriated the pelvic plates are narrow; elements of the upper part of the column, round and small making a slender support. Fig. 77, arrangement of the plates in horizontal projection.

CUPULOCRINUS (*d'Orb.*).

Scyphocrinus (*Hall*).

The saucer shaped pelvis is composed of five pentagonal pieces, and the head is made up of five series of elements. The five arms bifurcate.

C. HETEROCOSTALIS (*Hall*).

The column is round. The alternation of the plates is somewhat peculiar as described by Mr. Hall: the first from the pelvis is a plate with crenulated edges; second, a thicker joint with a round, smooth edge; and third, a thin one with a fimbriated edge. Trenton limestone.

TENTACULITES FLEXUOSUS.

Shell small, free and regularly tapering, section circular, surface annulated, annulations sharp and irregular in their distance from each other; longitudinally striated and somewhat bent or flexuous. This species is about one inch long and about a line in its greatest diameter, from which it tapers to a point; it has sharp, raised annulations or sharp ridges with striæ between.

In the Blue limestone of Ohio, there is a perfectly straight one, and smaller than the flexuous one. It may be a variety of the latter. Trenton limestone, Loraine shales.

ZOOPHYTES,

Or Polypi, possess a structure which serves at once to distinguish them from the Bryozoa and Sponges. The character of the former has been already stated, while of the latter it is necessary to say that their tissues are reticulated, and at the same time traversed by wide and winding aquiferous canals, and that their hard parts consist of simple spicula which are peculiar to this class of animals.

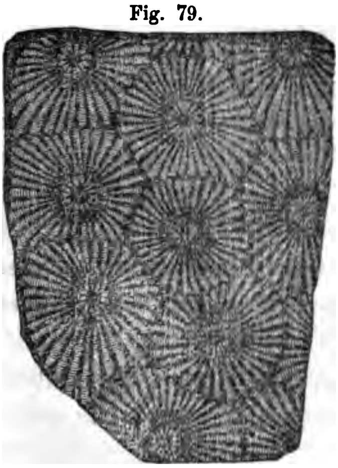
The hard or stony tissue of polypi or corals, has been technically called *sclerenchyma*. It belongs to the tegumentary system, or rather, it is a product of this system. The organization of the Zoophite being quite different from that of the Molusca, its hard, imperishable parts are necessarily quite different. The former, has but a single orifice for the double purpose of the reception of food and the rejection of the excrementitious matter. Its digestive cavity is a sack, and what is exterior to the digestive surface has the property of secreting the sclerenchyma which begins to be formed at a central point at the inferior part of the stomach. It is here the process of calcification begins, and from this it extends upward inclosing the gastric cavity in a cup, or cell whose form will vary according to the character of the individual which occupies it or is its maker. The cup or cavity may be cylindrical, or broad stellate open throughout or closed at the bottom. This cell or cavity in the stone corals is never perfectly simple, as the wall of calcified tissue grows upward, vertical lamina forming partitions grow from the inner surface towards the centre. Their number is always the same in the same species. These lamina or vertical plates are called *septa*. If they reach the centre and unite, they form a kind of vertical axis to the cell, which is the *columella*. The spaces between the septa are called *loculi*. When the outer surface of calcified wall sends out ridges or spines, they form *costæ*. The whole cell with its modifications forms a *calire*. In certain families the calice is open at both ends; in others it is closed at the bottom; and in others still, there is a repetition of transverse bottoms, tabula, or floors, which divide the calice into many small cells placed vertically one above the other. Fig. 78 shows the calice with its septa of the Cyathophylhum turbinatum extending from the wall towards the centre; the depression or the cup being produced by the discontinuance of the septa inwards.

Fig. 78.

3

The number of chambers formed by the septa is variable. They increase regularly in successive circles. The regular primary number being six; in each chamber there will be formed other septa in succession, constituting another circle. To this may be added two more, forming a third order of circles. The Polypiers increase or multiply in three different ways, by ova, by buds and by division. The simple polype is produced from ova, it is an isolated individual either free or fixed, the transverse section is usually round, as the Turbinolia. The second mode is by buds which results in the aggregation of individuals, but each individual is perfectly distinct from the others; the calice is generally circular, as in fig. 79, the Favastræ rugosa. The last mode, by division or fissiparity, the individual is divided and forms two individuals, this form also results in the aggregation of individuals; the calice is irregular, or oval, the elongation being the first step towards a division of the individual. The form therefore, of the calice, together with its mode of aggregation are important generic characters. The Polypiers are divided by M. Milne Edwards into three orders, the *Zoantharia*, the *Alcyonaria* and the *Hydraria;* the two former only, are represented in a fossilized state.

Fig. 79.



6

The general characteristics of the subkingdom Zoophita are, animals formed for a sedentary mode of life, being provided with a circle of retractile tentaculae around the mouth, and a central gastric cavity with only a single orifice, and in which are lodged the reproductive organs.

The Corallaria which forms a subclass under Zoophyta, embrace the calcareous corals which in form may be tubular, cyathoid or discoidal, but exclude all the cylindrical, tubular or horny sprigs, which bear bell shaped cells for the reception of contracted tentaculæ.

The Zoantheria embrace most of the known fossil stony corals. They have either a conical, tubular, simple or arborescent forms, and an internal gastric cavity divided vertically by a circle of septa, radiating from the internal wall of the corallum.

Family CYATHOPHYPLIDÆ.

The family embraces those corals whose septa are incomplete, or septa which do not extend from the bottom to the top of the visceral chamber, in the form of uninterrupted lamina.

STREPTOPLASMA (*Hall*).

"Corallum simple, and differing from Cyathophyllum by the structure of the wall, which is destitute of Epitheca, and covered with sublamellar costæ."—*Ml. Edwards.*

S. EXPANSA, *pl.* 3, *fig.* 6, 7, *a*, *b*.

Small, turbinate; cup deep; septa numerous. It is often worn down so as to present a forked, triangular form. Chazy limestone.

Mr. Hall has described five other species belonging mostly to the Trenton limestone, viz: *profunda, corniculum, crassa, multi-lamellosa, parvula.*

Family FAVOSITIDÆ.

"The coral is formed of lamellar walls, with little or no cænenchyma; visceral chambers divided by numerous and well developed complete tabulæ."

The family is divided into two tribes: 1. favositidæ, the corallum massive, with its walls perforated and its septa rudimentary, no cœnenchymæ. 2. Chætetinæ, corallum massive, walls not perforated, neither septa nor cœnenchymæ.

CHÆTETES.

The genus Chætetes is now regarded as a fossil of Carboniferous limestone; and the fossils which had been referred to Fischer's genus, are now, in part, placed in Monticulipora, (*d'Orb.*). In the Chætetes the *fissiparous* mode of reproduction prevails, while in the Monticuliparous, the mode of reproduction is *gemmiparous.*

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* Cœnenchyma; it is the cellular mass formed upon the outside of the wall of the corallum.

MONTICULIPORA (*d'Orb.*).

Monticulipora petropolitana.

Favosites lycopodites (*Vanuxem*).

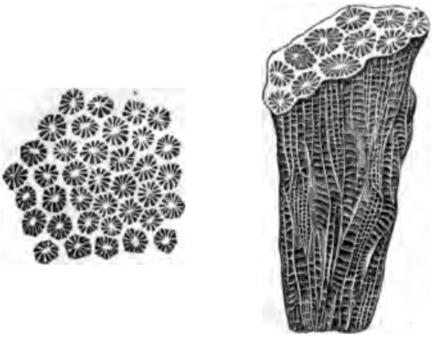
Chætetes lycoperdon of various authors, in part.

Fig. 80.

The species is thus defined, by MM. Edwards and J. Haimes. Corallum in general, free; basal plate flat or concave, and completely covered with concentrically wrinkled Epitheca; upper surface regularly convex; tabulæ complete and horizontal. The calices are unequal in size, polygonal, sometimes round; the largest one-fifth of a line in diameter; the floors and tabulæ are about one-twelfth of a line apart. The fossil is one of the most common in the Trenton limestone.

FAVISTELLA (*Hall*).

Fig. 81.



Coral massive, cellular, hexagonal; septa about twelve; cell walls with interposed cœnenchyma.

F. STELLATA.

Corallum hemispheric, spheroidal; the cell walls soldered, and the and are not separable, like the Favosite; Tabulæ nearly direct. Loraine shales. Fig. 81.

COLUMNARIA (*Goldfuss*).

C. ALVEOLATA.

Pl. 4, *fig.* 10.

Corallum massive, convex; calices arranged in parallel radiating columns; hexagonal; walls furrowed and separable, and without cœnenchyma; septa rarely if ever meet and form a columella, often obsolete. Chazy and Birdseye limestone.

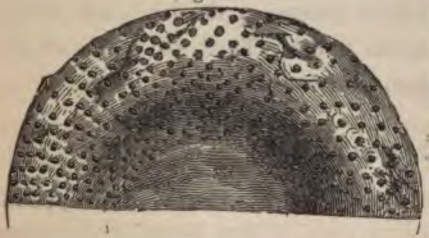
RECEPTACULITES NEPTUNI.

Pl. 14, *fig*. 1.

This fossil is described by Mr. Hall as suborbicular, hemispherical; depressed in the centre; it presents a series of quadrangular cells, within which there is a vertical, cylindrical tube opening upwards; opening not entirely circular.

R. CIRCULARIS (n. s.), *fig*. 82.

Fig. 82.



This coral is in the form of a thick, flattened ring, studded with circular cells, arranged in regular lines traversing it rather obliquely. It belongs to the Loraine shales.

AULOPORA (*Goldfuss*).

Aulopora arachnoidea, *fig*. 83.

Parasitic, fine and web-like, ramifying, branching; branches anastomosing with each other; tubes linear, narrow, enlarged at the point where the oval, slightly elevated, mouth is placed. Figure very much magnified. Trenton limestone.

Fig. 83.

GRAPTOLITES.

Diplograpsus pristis.

Graptolites dentatus (*Vanuxem's Report*).

Pl. 12, *fig.* 3.

Stem narrow; serrations acute; numerous varieties occur in which the serrations are more obtuse; the stem widens near its distal extremity, and is subject to variations from causes which affect the integrity of the rock in which it occurs. Utica slate.

PLANTS OF THE LOWER SILURIAN ROCKS.

The plants which have hitherto been discovered in the lower Silurian rocks, are without doubt marine. They are mostly in the condition of casts; the interior parts being replaced by amorphous matter We have not as yet found any in which the tissues are preserved, so as to afford us any clue to their structure. This is not all, it is the stem only which is preserved, its form being more or less distorted, while the softer and more perishable parts, the leafy appendages, are rarely met with.

The stems are more or less round, but somewhat flattened. These casts usually exist in an entangled thicket, so as to obscure still more their most common characteristics.

In the lower part of the calciferous sandstone we meet with the first beds of these obscure plants, which occur in what have been called fucoidal layers. The presence of these beds proves that a marine vegetation must have been luxuriant in certain localities. The fact itself, the existence of beds in the early palæozoic period, is that which most interests us. This, taken in connection with the probable fact that no land plant existed in the lower Silurian period, is one of the most decisive proofs that there has been a progression in the order of creation and that that progression may be observed as well in the vegetable as in the animal kingdom. It is admitted by our most acute and learned zoologists that marine animals and plants have a lower grade of organization than the terrestrial, and hence that they take a lower rank in the scale of being.

FUCOIDES DEMISSUS (*Conrad*).

Phytopsis tubulosum (*Hall*).

In the Birdseye limestone the characteristic fossil has been referred to the vegetable kingdom. I allude to the Fucoides demissus of Conrad, the Phytopsis tubulosum of Hall.

Fig. 84.

In my Geological Report of the second district of New York, I expressed the opinion that this fossil belonged rather to the animal than the vegetable kingdom. It certainly has few characters in common with the vegetables, whether we regard its external form, its growth, anastomosis or its internal structure. In connection with these peculiarities, I observed upon its surface at many places open circular cells which, under the microscope appeared to be connected with its internal cellular structure. These cells, it is true, may be incrusting ones; and foreign to the fossil, still, they appear connected at their bases and sides with the structure of the fossil. If so, it appears that the Phytopsis may be a Bryczoon, inasmuch as those cells which appear attached to its external surface belong to this division of the Molusca. It is clear, however, that it is not a coral.

Pl. 4, fig. 12, 13, exhibits its mode of growth traversing a bed vertically, anatomosing and diverging without showing that it has a main axis of development like a plant. Fig. 84 exhibits its structure obscurely, as it appears when upon the weathered surface of the Birdseye limestone.

APPENDIX,

Containing additional Descriptions of Fossils of the Taconic and Lower Silurian Systems.

GASTEROPODA.

STRAPAROLLUS PLANISTRIA (*Hall*).

Pl. 4, *fig.* 16, 17.

Shell small, depressed; volutions three or four; outer volution sharply angular; striæ flat and plain.

BELLEROPHON PROFUNDUS.

Pl. 17, *fig.* 7.

Volutions about three, contiguous, marginated, direct, gradually increasing in size; umbilicus deep; aperture somewhat lunate. Watertown, in the lower part of the Trenton limestone.

PLEUROTOMARIA PERCARINATA.

Pl. 5, *fig.* 7.

This fossil is found in the Trenton limestone at Middleville, associated with Atrypa hemiplicata, Cyrtolites compressus, and C. trentonensis, fig. 22. The gasteropoda of this locality though numerous, are rarely smooth and perfect, and hence there is some difficulty in identifying them.

P. SUBTILISTRIATA.

Pl. 6, *fig.* 11, 12.

Small, conical; spire depressed; volutions four or five; smooth, or the striæ extremely fine; aperture transverse and subtriangular. Trenton limestone.

DISCOLITES (n. g).

Shell minute, discoid; volutions one or two; texture corneo-calcareous; section circular, or apparently so; aperture round; no dilatation.

D. MINUTUS (n. s).

Shell microscopic, convolute, very thin, smooth, glossy, brown and fragile; volutions direct, scarcely contiguous; umbilicus distinct, smooth. It occurs rather abundantly in the Blue limestone of Cincinnati, associated with Berichia.

ACEPHALA.

CARDIOMORPHA SUBANGULATUS.

Pl. 12 *fig*, 7.

Edmondia subangulatus (*Hall*).

Shell large, wide; ventral margin wide, rounded; umbones rather prominent and thick or obtuse; no incurvation, prominence of the umbones extending in a low ridge towards the ventral margin. Surface marked with concentric lines of growth.

LYONSIA VETUSTA.

Cardiomorpha vetusta (*Hall*).

Pl. 13, *fig*. 8.

Form subrhomboidal; umbones prominent, obtuse; the concentric surface lines rather strong, distant, with finer intermediate ones.

L. MYTILOIDEA (*d'Orb.*).

Pl. 13, *fig*. 10, 11.

Shell elongated; anterior extremity rather narrow and gradually widening towards the margin, subcylindrical; umbones rather prominent and narrow; surface lines fine, but none left upon the cast.

L. SUBLATA (*d'Orb.*).

Pl. 13, *fig*. 1.

Mr. Hall describes it as subrhomboidal, gibbous and broadly rounded; umbones high, obtuse, not incurved, and with a shallow sinus in the margin; surface marked with imbricating lamina.

BRACHIOPODA.

ORTHIS COSTALIS (*Hall*).

Pl. 3, *fig.* 26 *a b and* 21 *c b.*

Valves strongly plicated; simple, valves unequally convex; ventral quite convex, the other rather flat; plaits about thirty-two, rounded; area rather large, triangular. This fossil occurs in thin beds in the Chazy limestone, particularly near the village of Chazy, Clinton county, N. Y.

STROPHOMENA INSCULPTA (*Hall*).

Pl. 3, *fig.* 22.

Small, valves semicircular; margin thickened; striæ sharp, elevated. Appear in the upper part of the calciferous sandstone, but more abundant in the Chazy limestone.

S. FASCIATA (*Hall*).

Pl. 3, *fig.* 24.

Semielliptical, somewhat punctated; striæ bifurcate near the margin. Chazy limestone.

S. LAEVIS.

Pl. 3, *fig.* 8.

Rather small, semielliptical, smooth. Birdseye limestone.

SPIRIFER TRENTONENSIS.

Pl. 15, *fig.* 20.

The spirifer occurs in the upper or gray portion of the Trenton limestone, at Watertown.

CRUSTACEA.

ILLAENUS ARCTURUS (*Hall*).

Pl. 3, *fig.* 12.

The distinctive characters appear in the width of the cephalic lobe at its junction with the thorax, the lateral extension of the cheek pieces, and in the more distinct development of the lobes of the cephalic shield. It belongs to the upper part of the calciferous sandstone. Chazy.

ASAPHUS MARGINALIS.

Pl. 3, *fig.* 16.

Axis with seven or eight distinct articulations; lateral lobes furrowed or with false articulations; margins entire.

ISOTELUS CANALIS.

Pl. 3, *fig.* 17, 18, 19.

The margin of the caudal shield is traversed with a rather deep furrow or channel; figs. 17 and 19 were found by myself at Chazy, in the calciferous sandstone, and were regarded by Mr. Conrad as new. In fig. 17 the margin only was preserved, the middle part having been worn away.

ASAPHUS OBTUSUS.

Pl. 3, *fig.* 14.

This fragment has received the name Asaphus obtusus, though too imperfect for determination.

CALYMENE CONRADI (n. s.).

Small, wide across the cheeks; cheek angles obtuse or rounded; posterior lobes of the glabella comparatively large and globular; thoracic lobes very convex, with a row of tubercles in the furrow or between the axis and lateral lobes. Loraine shales.

GRAPTOLITHINA.

DIPLOGRAPSUS LACINIATA (n. s.).

Pl. 1, *fig.* 24.

Stem narrow, cell mouths arranged; laciniate, or gashed serrations; acute, and rather elongated.

GLOSSOGRAPSUS SETACEUS (n. s.).

Pl. 1, *fig.* 20.

Stem rounded at the extremities, cell mouths or serrations bearing seta; serrations unequal, and in parts obsolete, or it may be obliterated by atmospheric influences. This species is evidently injured, and probably has lost its outer integument.

DIPLOGRAPSUS.

Pl. 1, *fig.* 3.

It is thin, olive green and foliaceous, but its characters too obscure to be determined with certainty.

DIPLOGRAPSUS AMPLEXICAULE.

Pl. 7, *fig.* 11 *a b*.

Cell mouths situated with or upon the sheathing scales or folioles, which are subacute.

DESCRIPTION OF PLATES.

PLATE I.

[NOTES RESPECTING PLATE I.—Fig. 4, which is referred to Orbicula is an outside cast in a very soft slate; it has been impossible to determine the texture of the shell. It resembles an Ancylus in shape and direction of the apex, but there are no certain marks by which I can determine whether the apex is directed forwards or backwards. It will probably prove to be a Helcion.

Fig. 9. I have allowed to stand as in the text a lingula, but the state of the valve at the umbo and the delicacy of the fossil, and the softness of the rock has raised a doubt in my mind respecting its perfection.]

Fig. 1. Cypricardia.
2. Lateral view of the mouths of cells of an indeterminate species.
3. Diplograpsus.
4. Orbicula excentrica.
5. Diplograpsus dissimilaris.
6. Nemagrapsus elegans.
7. do capilaris.
8. Microdiscus quadricostatus.
9. Lingula ?
10. Obolus ?
11. Diplograpsus secalinus.
12. Cladograpsus sp. indet.
13. Diplograpsus foliosus.
15. Cladograpsus dissimilaris.
16. Atops trilineatus.
17. Lingula striatus.
18. Eliptocephalus asaphoides.
19. Diplograpsus ciliatus.
20. Glossograpsus setaceus.
21. Staurograpsus dichotomous.

22. Diplograpsus obliquus.
23. Undetermined.
24. Diplograpsus laciniatus.
25. Glossograpsus ciliatus.
26. Diplograpsus rugosus.
27. Monograpsus elegans.
28. Monograpsus rectus.

PLATE II.

Fig. 1. Buthotrephis rigida.
2. Nereograpsus Jacksoni.
3. Nereograpsus Deweyi.
4. Nereograpsus lanceolata.
5. Nereograpsus Loomisi.
6. Nereograpsus gracilis.
7. Nereograpsus robustus.
8. Palæochorda marina.

PLATE III.

Fig. 1. Enallopora?
3. *a*, E. aspera.
4. *a*, 5 *a*, Sulcopora fenestrata.
6. Straparollus sordidus (weathered).
7. *a*, 7 *l*, 6, Streptoplasma expansa.
8. Strophomena lævis.
9. Crinoid joints and fragments.
10. Actinocrinus.
11. Asterias plate.
12. Illaenus arcturus.
13. I. Crassicauda.
14. Asaphus obtusus.
15. Pygidium, asaphus ?
16. Asaphus marginalis.
17. Isotelus canalis.
18. 19. I. canalis.
20. Spine of the Ceraurus.
21. *b c*, Strophomena plicifera.
21, 22, 23. Strophomena insculpta.
23. Atrypa dubia
24. Strophomena fasciata.
25. Atrypa pleva.

26. Orthis costalis.
27. Atrypa acutirostra.
28. *a b*, Atrypa plena.
29. Atrypa plicifera.
30. Atrypa altilis.

PLATE IV.

Fig. 1. 1 *a*, and 14, Ptilodictya ramosa.
2. Straparallus labiatus.
3. and 14, Ptilodictya labyrinthica; 3, enlarged.
4. Bellerophon sulcatinus.
5. Cast of the Orthis, testudinaria.
6. Orbiculoidea.
7. Lingula prima.
8. Orthocera multicameratus.
9. Lingula acuminata.
10. Columnaria alveolata.
11. Murchinsonia abbreviata.
12. Fucoides demissus enlarged cells.
13. do do
15. Straparollus magnus.
16, 17. Scalites.
18, 22. Ptilodictya labyrinthica, pores enlarged.
21. Scalites angulatus.
20. Scalites striatus.

PLATE V.

Fig. 1. Straparollus levatus.
2. S. complanatus.
3. Crinoidean plate.
4. Orthoceras primigenius; 4, *a b*, Pleurotomaria umbilicata.
5. Pleurotomaria indenta, left corner; and P. ambigua, right corner.
6, and 11. Murchinsonia bicincta.
7. Pleurotomaria percarinata.
8. 18 *a* 18 *b*, Turbo obliquus.
12. 1 *a b*, Murchinsonia bellicincta.
13. M. abbreviata.
14. 14 *a*, Lituites undatus.
17. Turbo symmetricus.
22. Cyrtolites trentonensis?

PLATE VI.

Fig. 1. Helcion subrugosa.
2, 3, 22, 23, 24. Cyrtolites bilobatus.
4, 5. Cyrtoltes acutus.
7. Bellerophon expansus.
8, 9, 27. Bellerophon bidorsatus.
10. Pleurotomaria rotuloides.
13. P. lenticularis.
11, 12. Var. subtilistriata ?
19. *a b*, Turbo ventricosus.
20. T. Americanus.
21. Loxonema subelongata.
25, 26. Cyrtolites subcarinatus.

PLATE VII.

Fig. 1. 1 *a*, *b*, *d*, Ptilodictya recta.
3. *a*, *b*, *c*, Ptilodictya acuta.
4. *a* to *g*, Ptilodictya elegantula.
5. Enallopora perantiqua.
6. Aulopora arachnoides.
7. 7 *a*, Ptilodictya ramosa.
8. *a*, *b*, *c*, Subretopora reticulata.
9. Retopora foliacea.
10. Stellipora antheloidea.
11. Diplograpsus amplexicaule.

PLATE VIII.

Fig. 1. Lingula attenuata.
2. L. riciniformis.
3. L. equalis.
4. L. quadrata.
5. L. elongata.
6. L. curta.
7. L. obtusa.
8. L. crassa.
9. Orbiculoidea filosa.
11. O. lamellosa.
11. Trematis terminalis.

PLATE IX.

Fig. 1. Orthis testudinaria, 1 *a* to *l*.
2. O. subequata.
3. O. bellarugosa.
4. O. disparilis.
5. O. perverta.
6. O. æqualis.
7. O. fissicosta.
8. O. tricenaria.
9. O. plicatella.
10, 11. O. pectinella.
12. O. insculpta.
13. O. dichotoma.

PLATE X.

Fig. 1. Atrypa extans.
2. A. nucleus.
3. A. bisulcata.
4. A. deflecta.
5. A. recurvirostra.
6. A. exigua.
7. A. circulus.
8. 9. A. ambigua.
10. A. hemiplicata.
11. A. extans.
12. A. subtrigonalis.
13. A. increbescens.
14. A. dentata.
15. A. modesta.
16. A. sordida.

PLATE XI.

Fig. 1, 5 *b*, 3, 7. Strophomena alternata.
2. S. planumbona.
4. *a*, *b*, *c*, *d*, S. tenuistriata.
6. *a*, *b*, *c*, *d*, *e*, *f*, S. sericea.
8. *a*, *b*, 9 *c*, *e*, S. filitexta.
7, 10. S. alternistriata.
12. S. planoconvexa.

PLATE XII.

Fig. 1. Endoceras proteiforme.
2. Oncoceras constrictum.
3. Diplograpsus pristis.
4. Orthoceras arcuoliratum. 4. Cyrtolites filosum. O. tereteforme.
5. Endoceras proteiforme.
7. *a*, *b*, Bellerophon exhaustus.
10 *a*, *b*, 5 and 11. Cyrtolites compressus.
13, 14 *a*, *c*, *d*, 15 *a*, *b*, *c*. Trocholites ammonius.
12, 11, 5. Bellerophon punctifrons.

PLATE XIII.

Fig. 1. Lyonsia sublata.
2. Cypricardia subtruncata.
3. Lyonsia subaviculoides.
5, 6. Posidonomya bellistriata.
7. Cardiomorpha subangulata.
8. Lyonsia vetusta.
13, 15. Cardiumorpha ventricosa.
14. Orthonota parallela.
16, 17. Cardiomorpha subtruncata.
18, 19. Ambonychia orbicularis.
20, 21. Posidonomya amygdalina.
22. Posidonomya orbiculata.
23, 25. Ambonychia subundata.
27. Avicula elliptica.
28, 29, 30. A. trentonensis.
31. A. subarcuata (not referred to).

PLATE XIV.

Fig. 1 *a*, *b*, 1. Receptaculites neptuni.
2. Lyonsia sanguinolaroidea.
3. Lyonsia gibbosa.
4. Lysonia trentonensis.
5, 6. Cardiomorpha ventricosa.
7, 8. Lysonia dubia.
14, 15. Lysonia faba.
10. Leda levata.
11. Cypricardia americana.
9 *a* to *p*. Orthis lynx.

PLATE XV.

Fig. 1. *a* to 1 *k*, Ceraurus pleurexanthemus, and its parts.
2. *a* to 2 *e*, Ceraurus vigilans.
2, 5, 18, parts of the Lichas trentonensis.
3. *c d e* and 7 7 *a b c*, Phacops caliocephalus.
4. *a*, head of the Trinucleus concentricus; 4 *b*, showing the length of the spines as it usually occurs in the Trenton limestone.
6. Acidaspis Spiniger.
7. *a*, head; and *c*, eye of the P. caliocephalus.
8. and 11. Asaphus extans.
12. Triarthrus beckii.
13. Illaenus trentonensis.
15. Illaenus crassicauda.
16. Calymene senaria.
18. Pygidium.
19. Head and parts of the Senaria, showing the direction of the great suture, and the form of the rings.
20. Spirifer trentonensis.
22. Strophomena nasuta.

PLATE XVI.

Fig. 1. 1 *a b* 3, varieties of the Endoceras proteiforme showing the surface markings.
4. *a b c d e f*, Conularia trentonensis.
5. *a b*, C. granulata.
6. C. papilata.
7. *a*, C. gracile.
7. Head of the Trinucleus concentricus.
8. Part of the head of the Ceraurus pleurexanthemus.
9. Part of the lobe of the Isotelus gigas.
10. Middle lobe of the head of the Isotelus.
11. Epistoma of the Isotelus.
12. Isotelus gigas.

PLATE XVII.

1. Trinucleus concentricus of the Loraine shales.
2. Strophomena alternata.
3. S. nasuta.
4. Lyonsia subtruncata.
5. Orthis crispata.

6. Tentaculites flexuosa.
7. Bellerophon or Cyrtolites profundus.
8. Pleurotomaria indenta.
8, *a* 8. Lyonsia submodiolaris.
9, and 16. Murchinsonia gracilis, cast.
9, *a b*, Pleurotomaria subconica.
10, *c*, Cyrtolites bilobatus.
10. Avicula demissa.
12. Orthis testudinaria of the Loraine shales.
13. Triarthrus beckii. Utica slate.
13. *a*, Pleurotomaria lenticularis.
14. Lyonsia anadontoides.
15. Avicula insueta.
16. Murchinsonia gracilis.
17. Periploma planulata.
18. Lingula quadrata.
19. Orthoceras.
20. Heterocrinus heterodactylus, joint.
21. Porcelia ornata.
22. Cardiomorpha poststriata.

PLATE XVIII.

Fig. 1, and 2. Encrinal heads disputed, exhibiting the mode of distinguishing their different elements. B, is applied to the immediate part to which the pelvis is attached; E, pelvis; F, costal plate; S, intercostal plate; H, scapular plate; I, interscapular plate.

2. K, arms Lecanacrinus macropetalus; L, cuneiform, joint; M, hand; N, fingers.

3. Elementary parts of the trilobite from Burmeister; under side of the Asaphus cornigerus; 4, upper side of the same; *a*, clypeus; *b b*, antennae bearing lobes; *c c*, lateral lobes; *e e*, mandibulae; *f f*, indentations into which the lateral lobes are placed when the animal rolls itself up; *h*, rectum; *d*, Labrum.

5. Illaenus crassicauda.

6, 7, 8. Views of the Asaphus, when rolled up.

9. Front view of the Illaenus rolled up.

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PART II.

Plate 1.

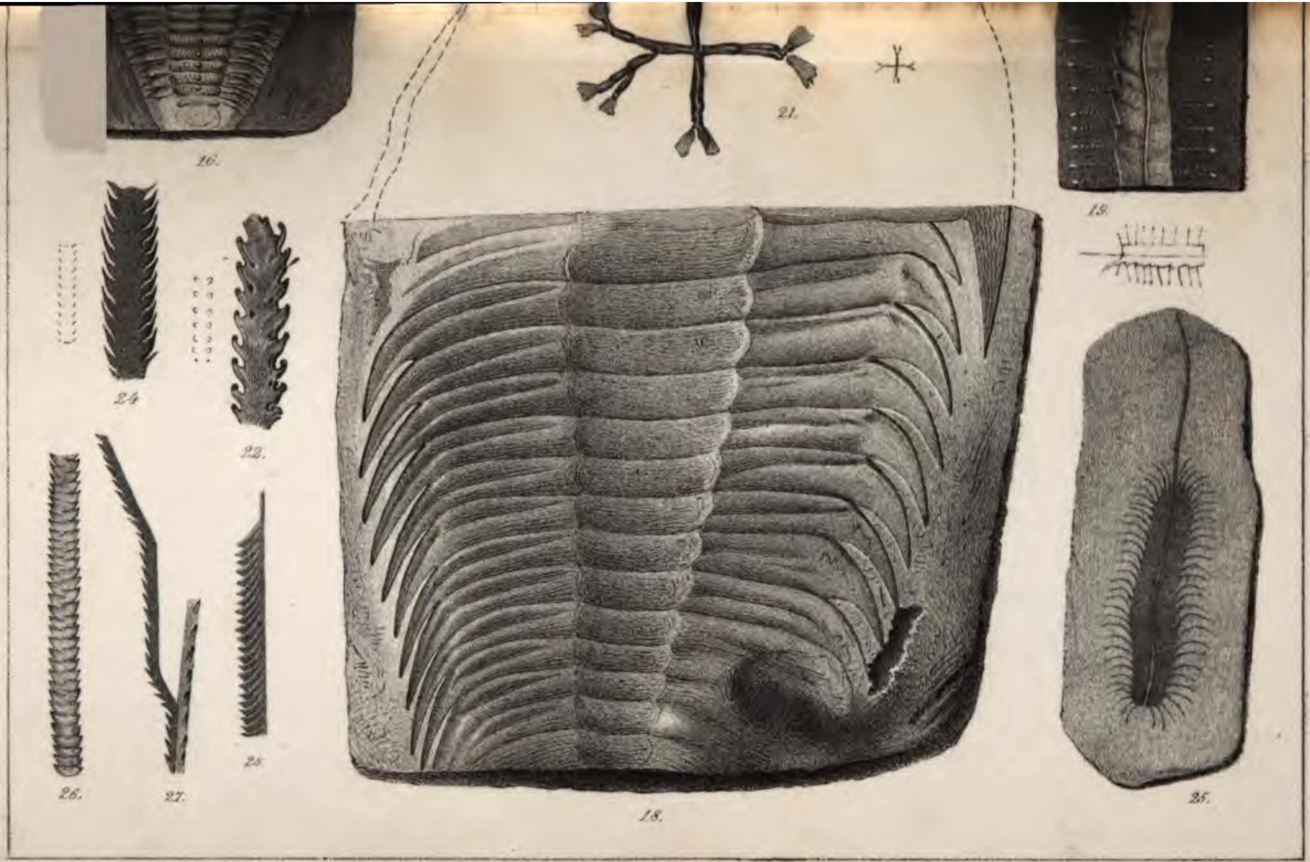
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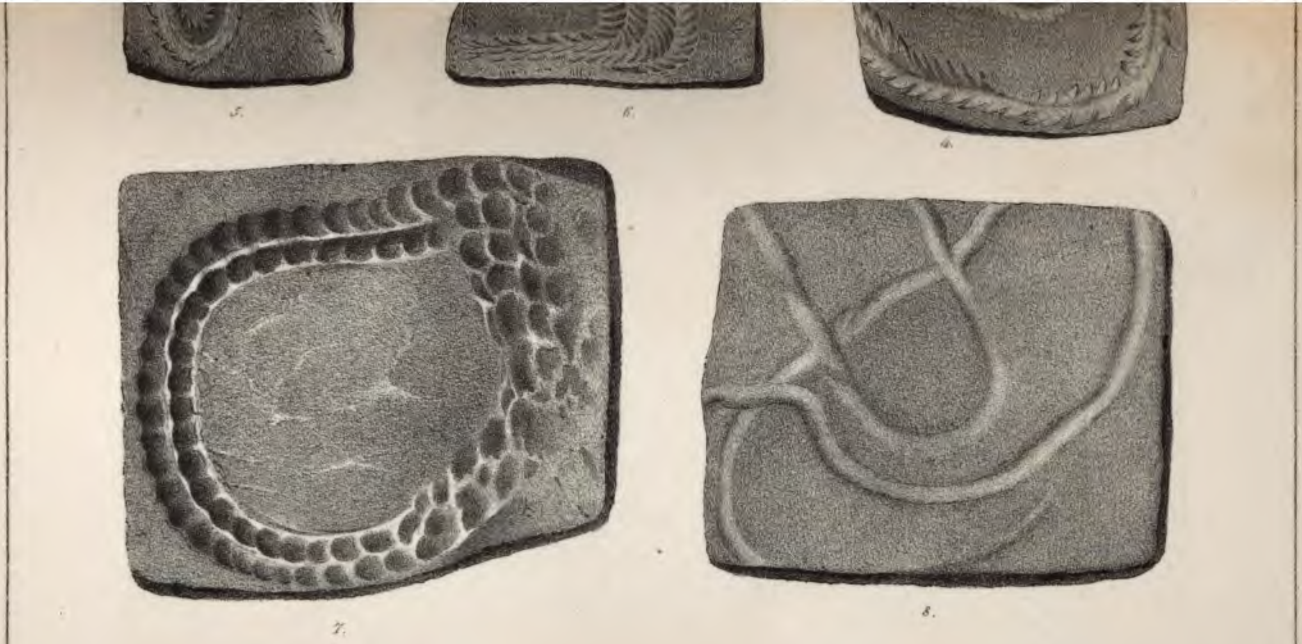
Plate 2.

Plate 2.



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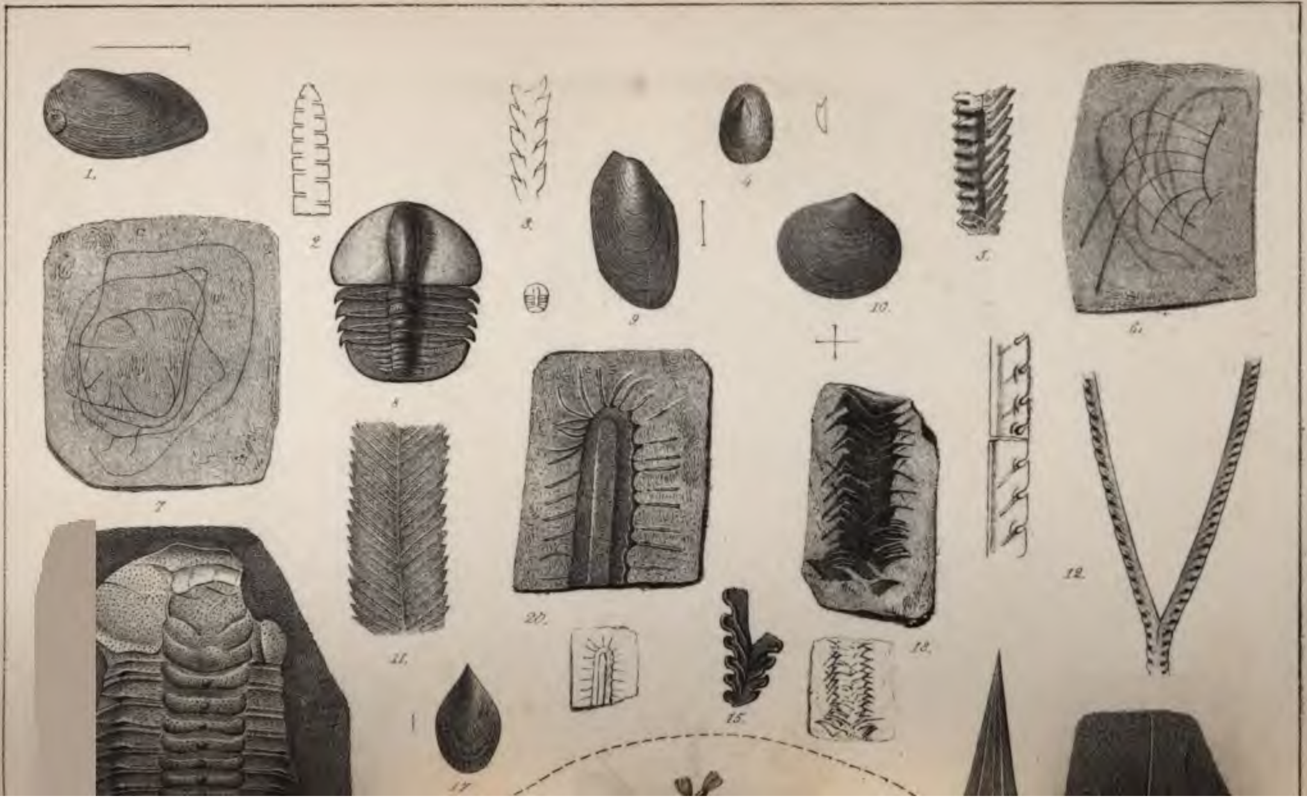
E. Emmons Jr. Del. On Stone by F. J. Swinton. Lith. of J. Murray. Albany.

Plate 1.



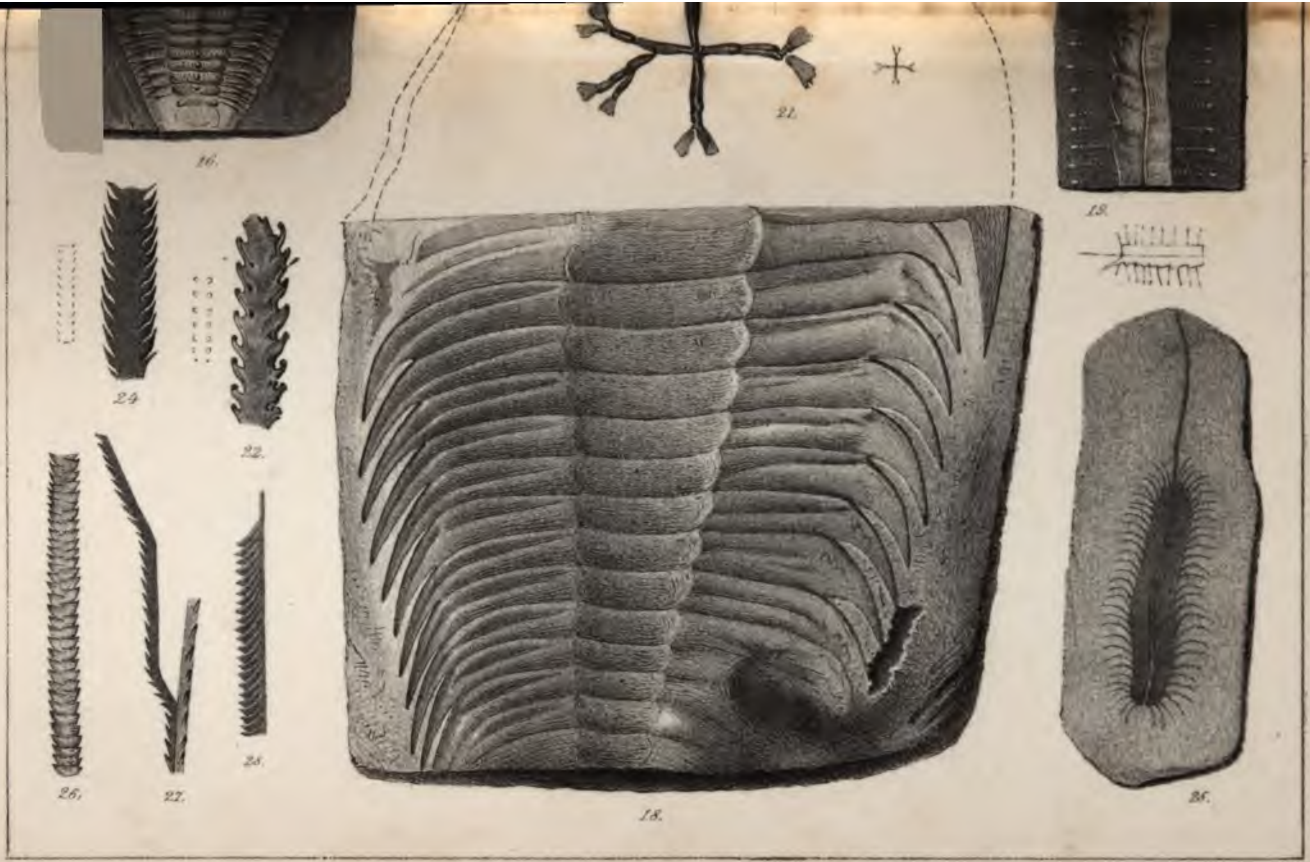

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PLATE V


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PLATE V

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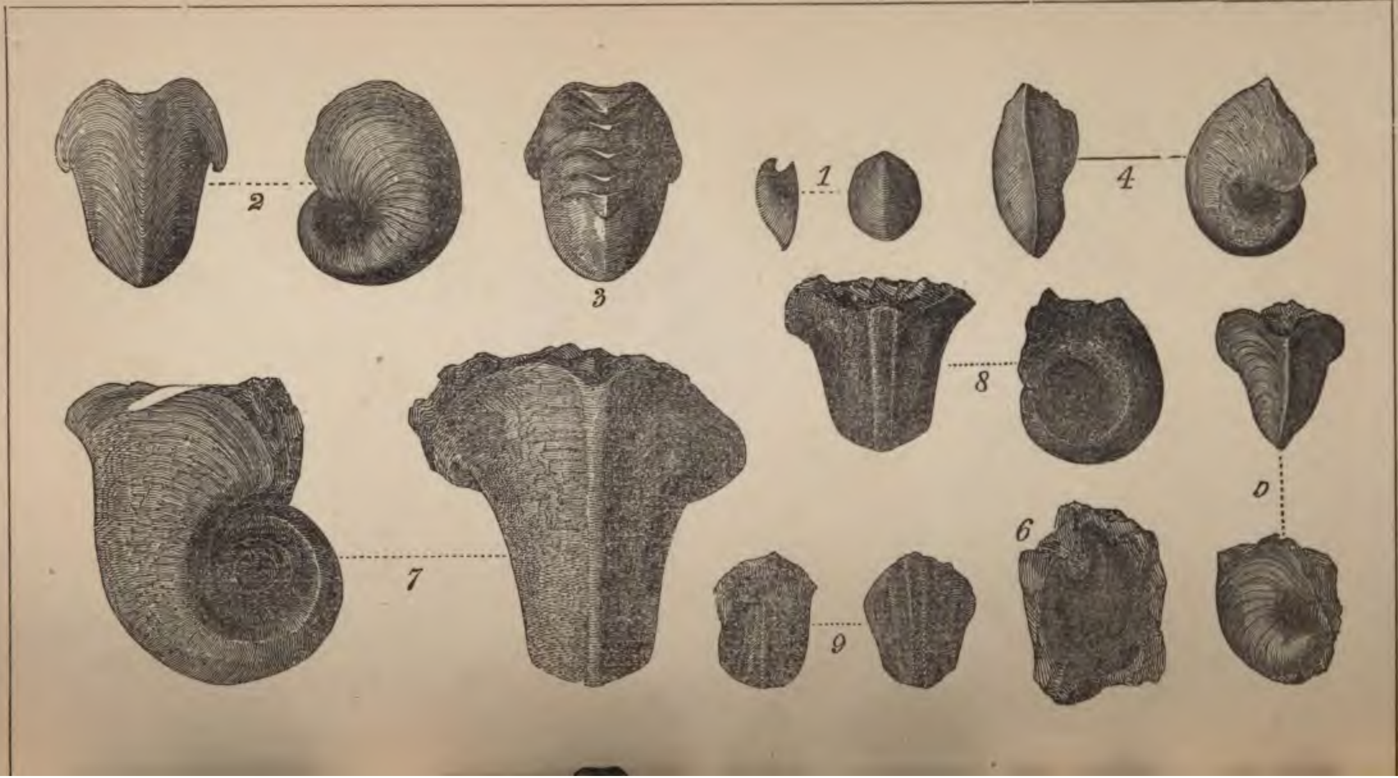
PLATE VI.



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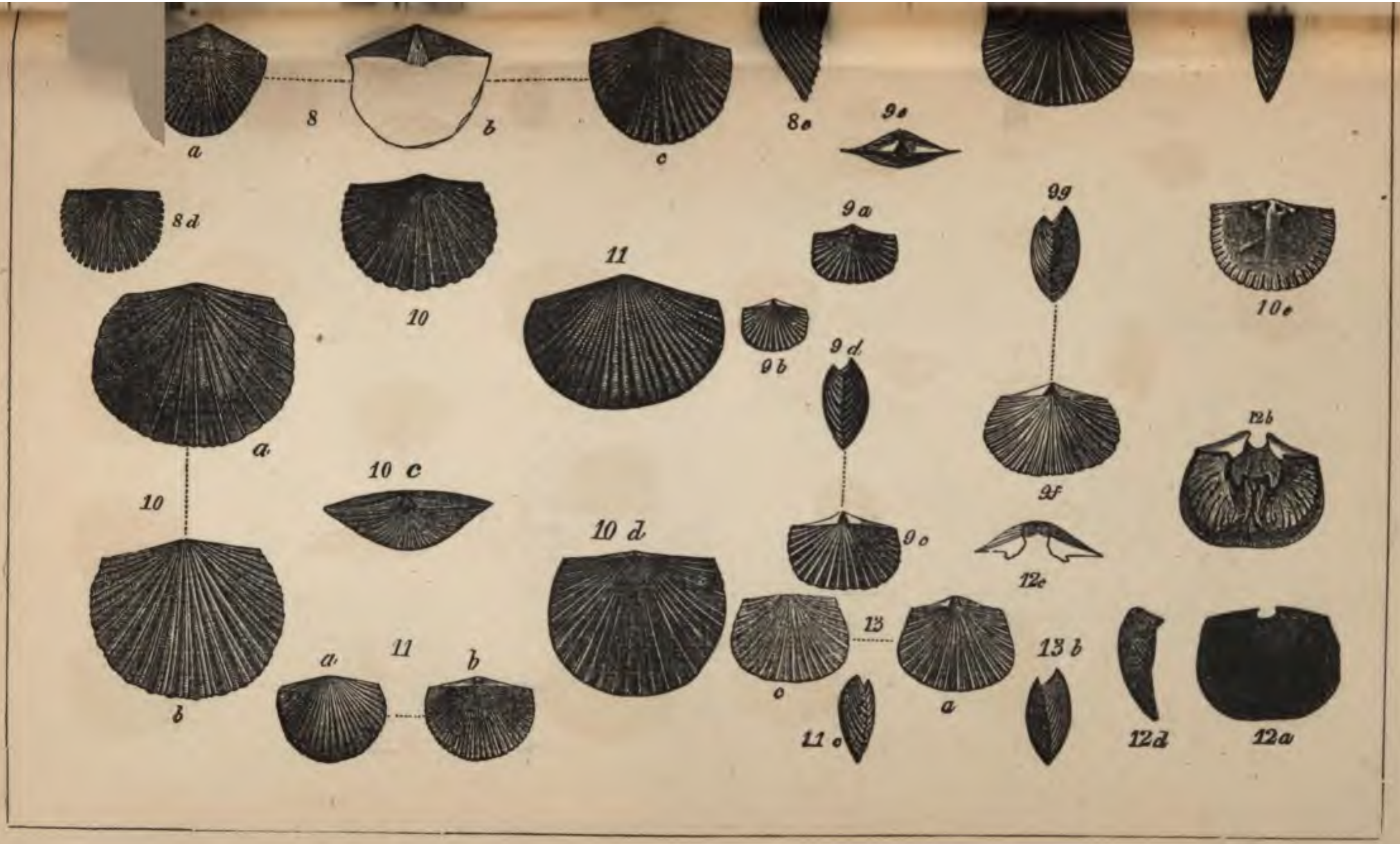
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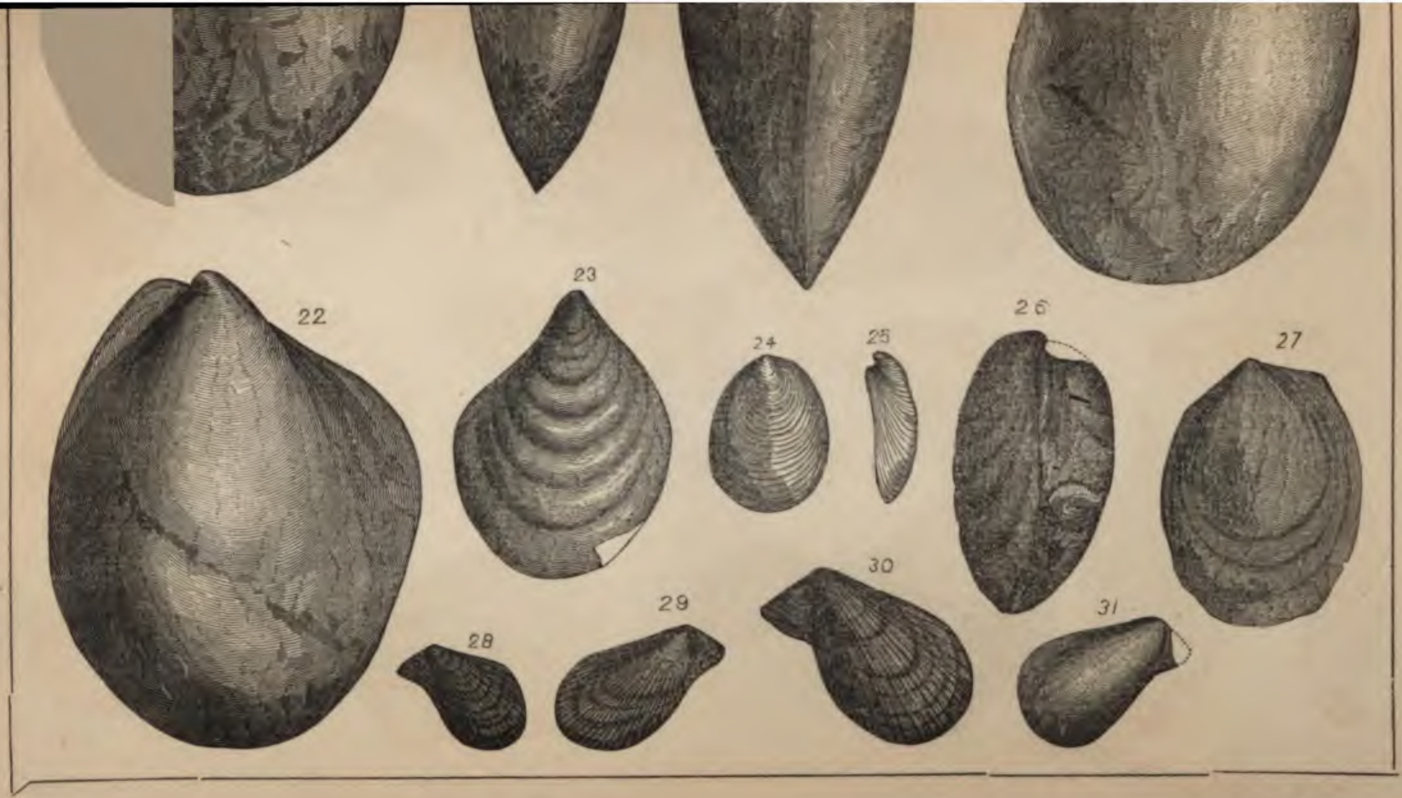
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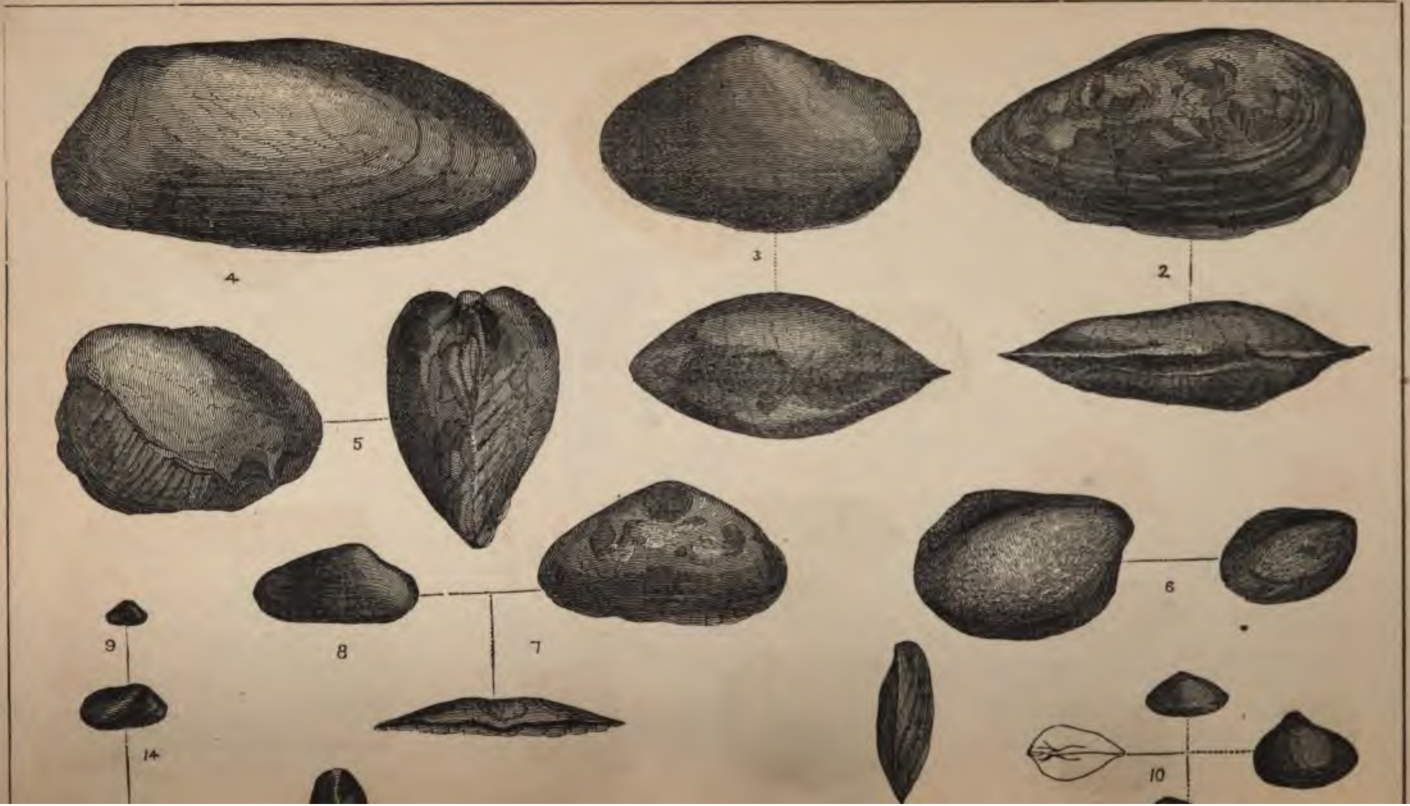


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PLATE XV.


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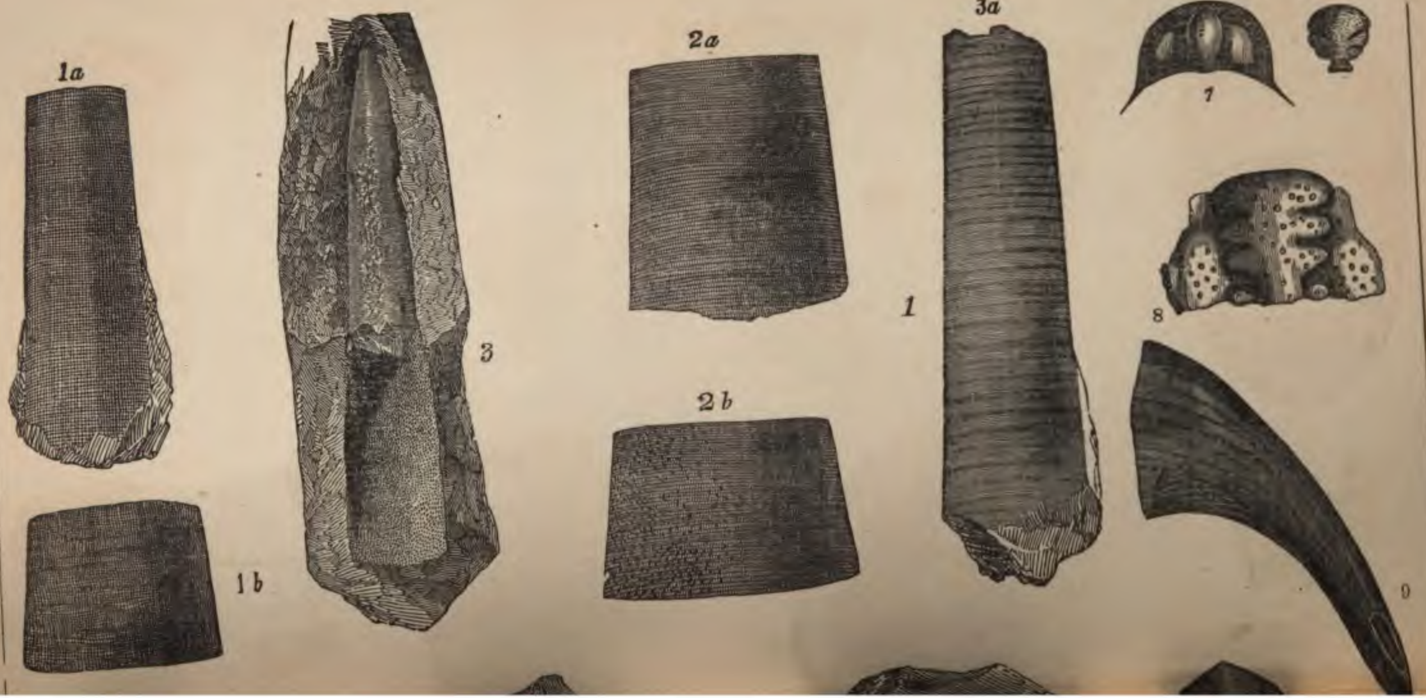
PLATE XVI.



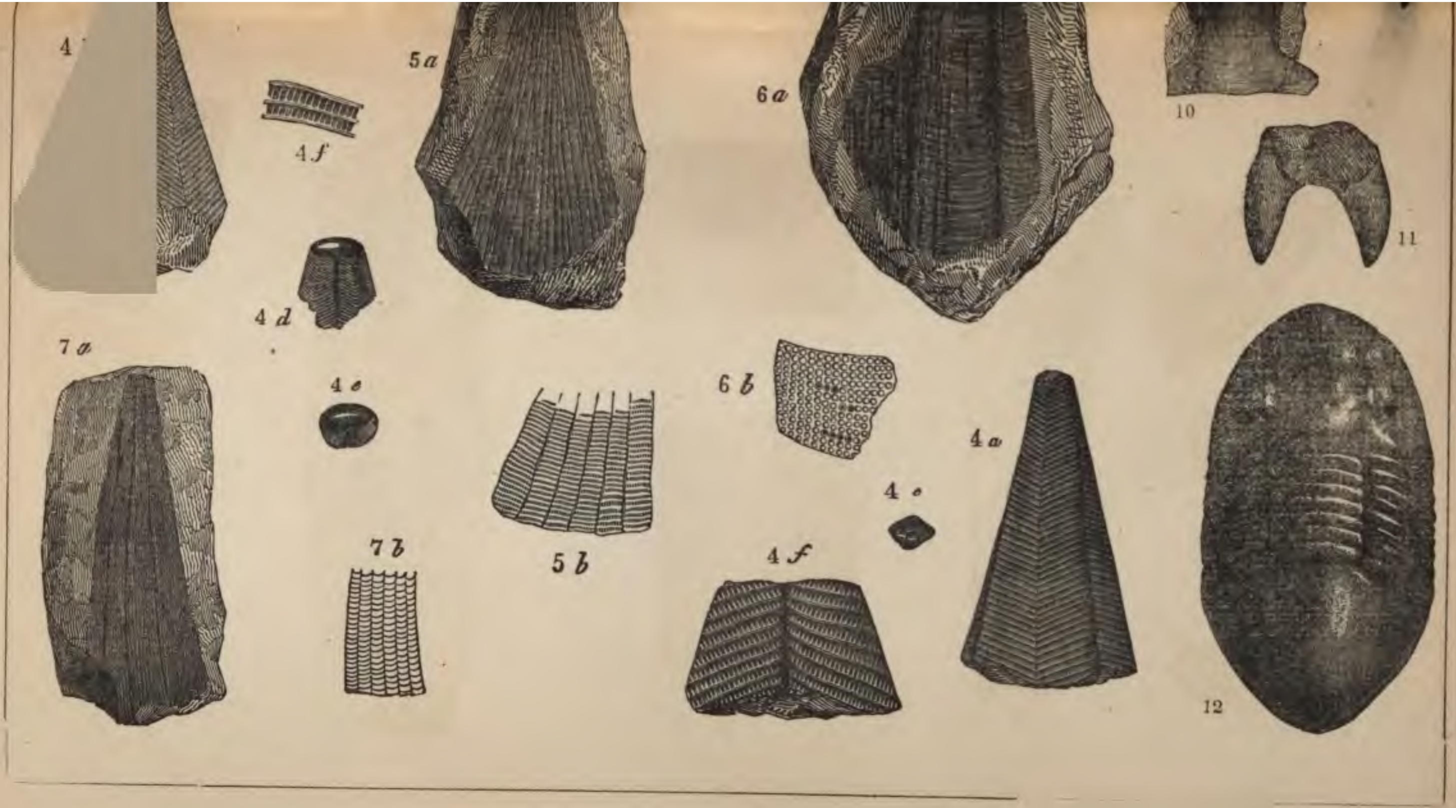

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PLATE XVII.

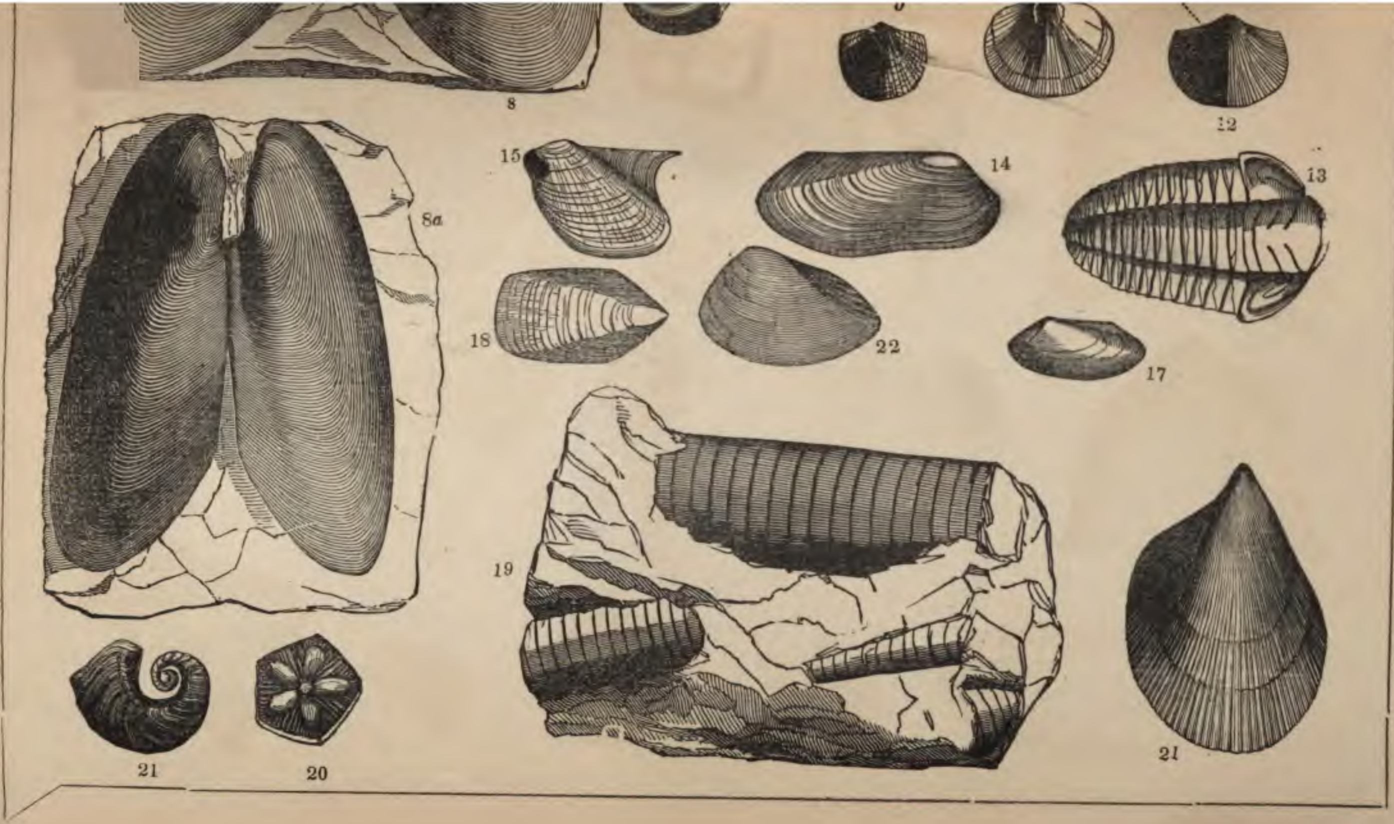
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PLATE XVIII.

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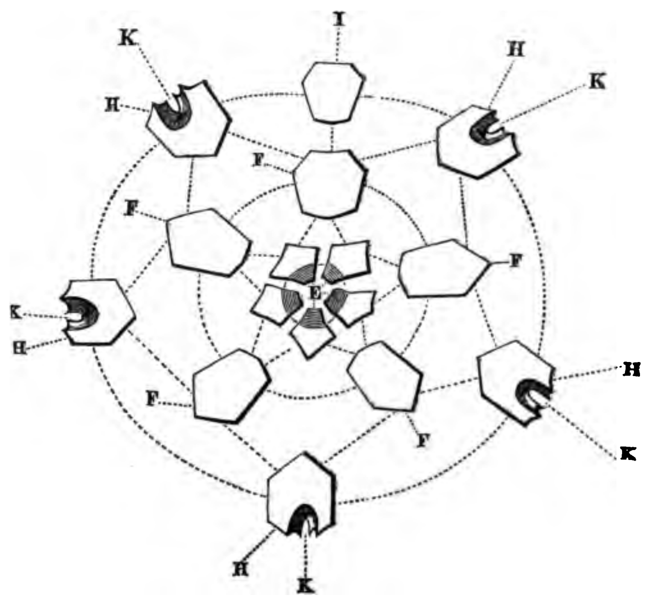

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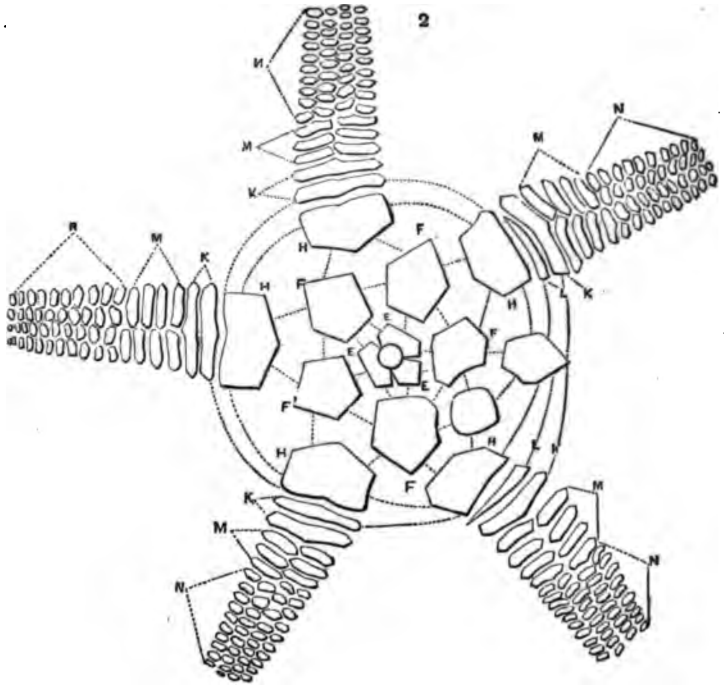

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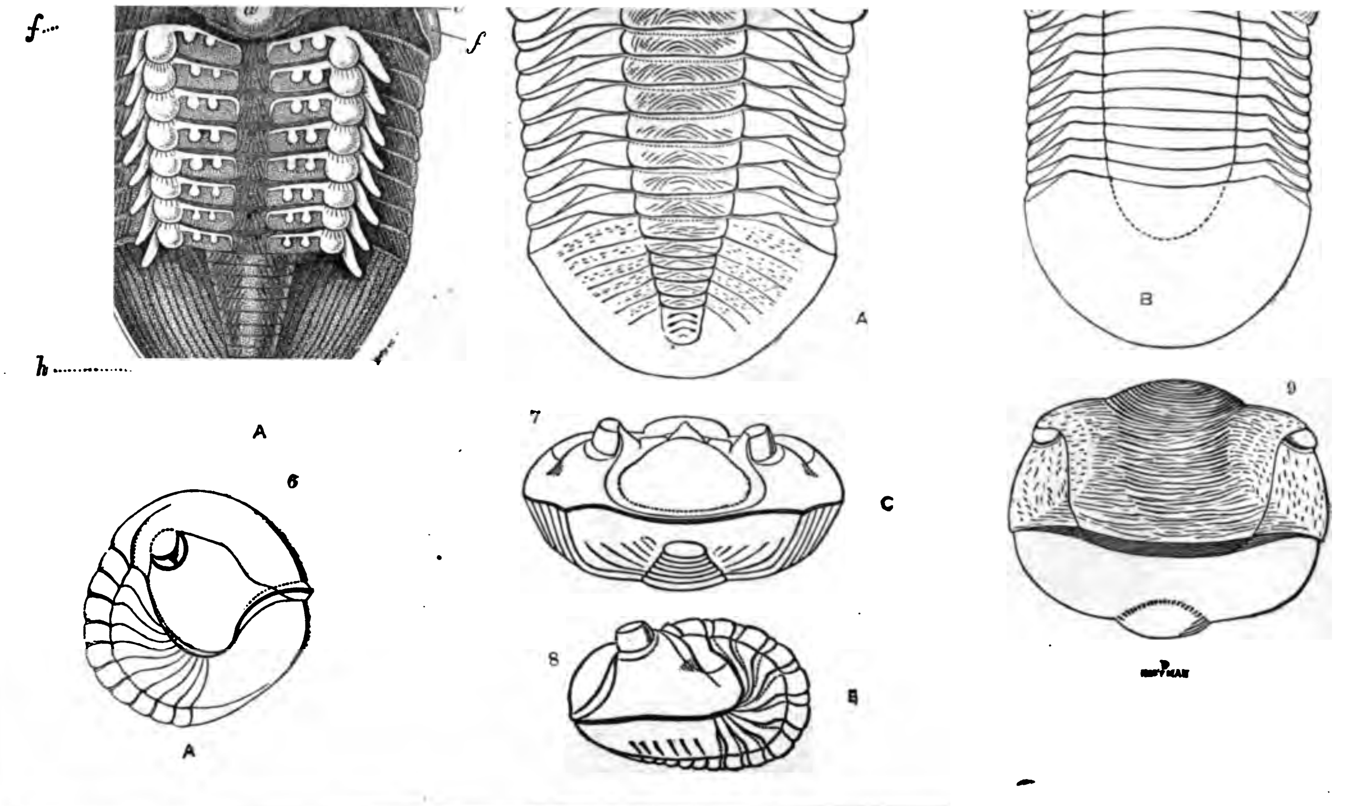

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